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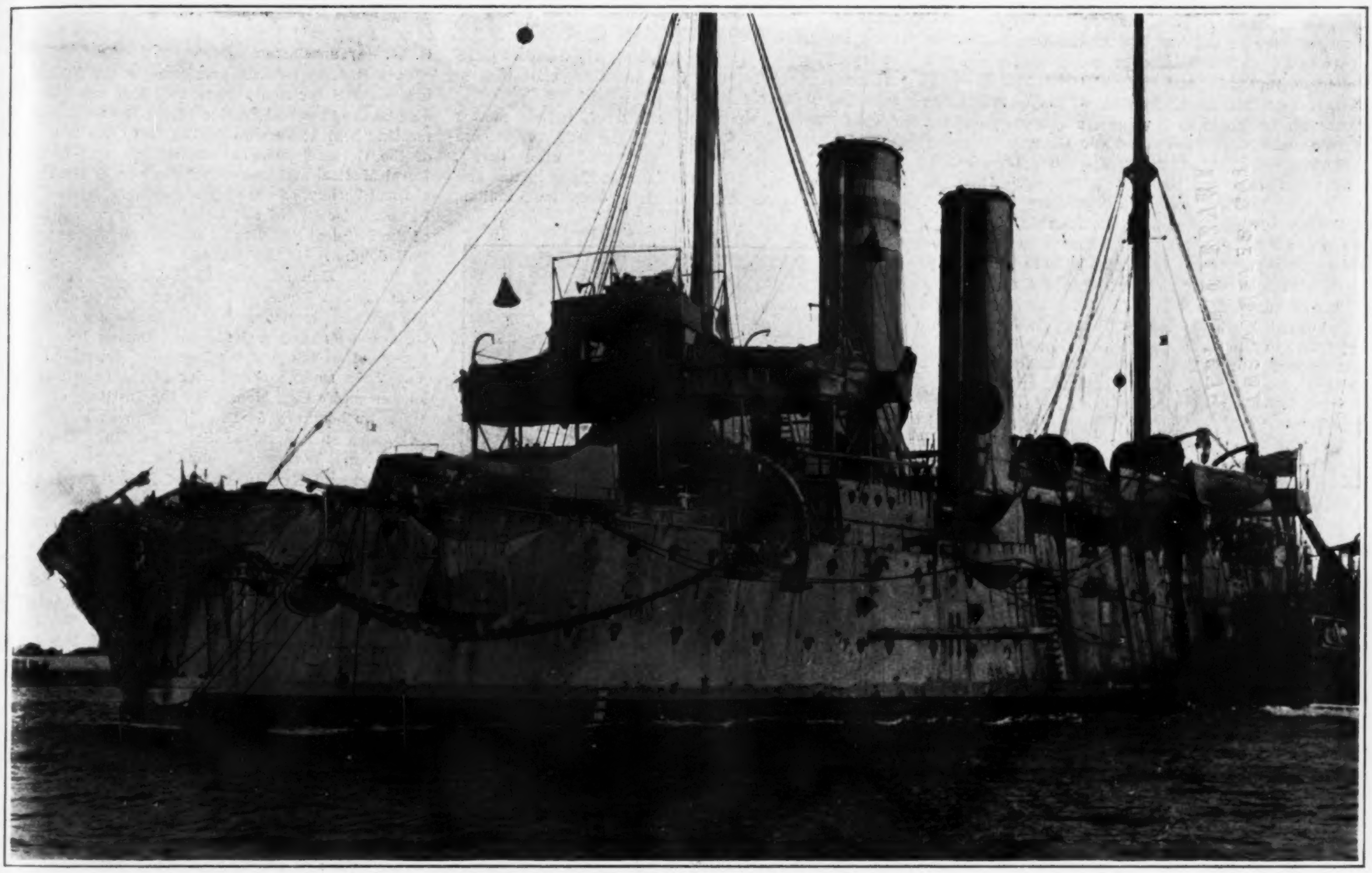


The Cruiser Hawke Coming Into Harbor After the Collision

This Wooden Structure is Covered With Canvas and Forms the Core for a Wax Cast.

THE HAWKE-OLYMPIC COLLISION—[See page 116].

Sir William Ramsay

Who Has Realized the Alchemists' Dream, the Transmutation of an Element

By P. F. Mottelay

Sir William Ramsey was born at Glasgow, October 2nd, 1852. His grandfather was a very prominent chemist in his day, and founded, in 1800, the Glasgow Chemical Society, of which he became the first president. His father was a civil engineer and brother to Sir Andrew Crombie Ramsay, who was president of the Geological Society, 1862-1864, and president of the British Association, 1880, and his mother was Catherine Robertson, the daughter of Archibald Robertson, M.D., who practised in Edinburgh, and who was the author of two well-known handbooks for students entitled *Colloquia Anatomica* and *Colloquia Chemica*. He married, in 1881, Margaret, daughter of George Stevenson Buchanan, by whom he has one son and one daughter.

At an early age he entered the Glasgow Academy and remained there until his fifteenth year, when he was received at the Glasgow University. There he commenced his first studies in chemistry under Prof. Anderson, while at the same time following laboratory work under Mr. Tatlock, a well-known analyst of the time. Four years later (1871) he went to Tübingen to study chemistry under Prof. Fittig, and from the time of his graduation there in 1872 up to the year 1874 he acted as chief assistant to the "Young" Chair of Technical Chemistry in Anderson College, Glasgow, which he left to occupy, until 1880, the post of tutorial assistant in the chemical department at Glasgow University. In 1880 he was appointed professor of chemistry at the University College of Bristol, becoming principal of the same college one year later, both of which posts he retained until 1887, when upon the resignation of Prof. Williamson, he was elected to the chemistry chair in University College, London.

Prof. Ramsey did not long continue investigations in the field of organic chemistry, with which his name was at first identified, preferring to enter the then new branch of physical chemistry, which he justly thought was likely to afford more extensively advantageous returns, and of which he was destined to become the leading exponent in his country. This recognition attaches to him by reason of the laborious, indefatigable researches which he carried out mainly in conjunction with Prof. Sydney Young, and the admirable results of which have been chronicled in all of the leading scientific publications of the time.

During 1894 he and Lord Rayleigh discovered the element argon, one and a half times heavier than air, the existence of which had, in the year 1785, been first suspected by Henry Cavendish (1731-1810), but which had not subsequently attracted attention. Their joint discovery was first made known publicly at the British Association meeting held at Oxford, and naturally attracted universal attention, for, as Prof. Thorpe remarked, it introduced novel considerations into the discussion of questions as the nature of chemical affinity and relations of the chemical elements to one another.

In the year following, 1895, he obtained, from a mineral called cleveite, another gaseous element, helium, which latter had first been recognized in the sun during the eclipse visible in India on August 18th, 1868, but which was absolutely unknown in terrestrial matter. That solar discovery was the joint work of Sir Edward Frankland, English chemist (1825-1899), and of Sir Joseph Norman Lockyer, English astronomer, and they had been able to accomplish it solely through the spectroscopic method initiated by the French astronomer, Pierre J. C. Janssen. The discovery of helium resulted from a number of investigations which Sir William carried out in the expectation of finding a substance containing *argon* (meaning inert) combined with other elements and of thereby ascertaining more information regarding its chemical properties. The spectrum of the gas which he obtained from cleveite proved to contain argon as well as a yellow line hitherto unknown, and when Sir William Crookes was asked to pronounce upon it he confirmed the fact that this yellow line was identical with that discovered through the researches of Janssen, Frankland and Lockyer. Helium has since been found in several waters and in other minerals generally containing either thorium or uranium. It is the next lightest gas to hydrogen, and proves to be the most difficult of all gases to liquefy. The latest figures given for it by Prof. Kammerlinghonnes of Leiden, who has succeeded in liquefying it, are: Boiling point, 4½ degrees; critical temperature, 5½ deg. Cent. absolute; critical pressure, 2¼ atmospheres.

Prof. Ramsay has since discovered, in conjunction with Dr. Morris W. Travers, during 1898, three more gaseous elements which were called *neon* (new), *krypton* (hidden) and *xenon* (strange), and he has also found along with Mr. Frederick Soddy that radium,

William Ramsay.

in its apparent disintegration, actually evolves helium. The discovery of the new elements, which differ from all others in so much that they cannot form compounds with one another or with other known elements, was deemed so important as to call for especial mention of the fact by the eminent chemist M. Berthelot (1827-1907) before the Paris Académie des Sciences, and it will be interesting to note that, in chapter VIII. (pages 234-269) of the third edition of "The Gases of the Atmosphere," Prof. Ramsay shows that the amounts of these rare inactive gases were found to be, approximately, as follows:

	In Crude Argon. One Part in—	In Air. One Part in—
Helium	2,300	245,300, by volume
Neon	757	80,800 " "
Krypton	200,000	20,000,000 " "
Xenon	1,700,000	170,000,000 " "

At page 113 of "The experimental study of gases" by Dr. Morris W. Travers, London, 1901, we find the atomic weights of the above named to be as follows: Helium, 3.96; Neon, 20; Krypton, 82; Xenon, 128.

During 1903, Sir William Ramsay and Mr. F. Soddy made the very important discovery that helium is developed by a spontaneous change in the radium emanation, and, four years later, Sir William and Mr. Cameron further proved that neon and argon are likewise produced from radium emanations. Other results obtained by these investigators in the same channel are detailed through the chapters treating of the general phenomena of radioactivity and of the transmutations of radioactive substances in the treatise just issued by G. W. de Tunzelmann.

Prof. Ramsay held the presidency of the Bristol Naturalists Society from 1884 to 1887 and was also president of the Chemical Section of the British Association meeting held at Toronto during 1897. He is a Fellow of the German Chemical Society, as well as of the Royal Medical and Chirurgical Society, of the Pharmaceutical Society, of the Chemical Society, London, of the Physical Society, of the Royal Society of London and of the Physical Societies of Manchester, Rotterdam and Philadelphia. He is a member of the Royal Academies of Berlin, Holland, Ireland, Bohemia, Turin, Stockholm, Leyden, Rome, St. Petersburg, Roumania, Vienna, Norway and Sweden, and of the Academies of America, Geneva, Frankfort and Mexico. During 1895, he was decorated an officer of the Legion of Honor and he has since been made a commander of the Crown of Italy, as well as Foreign Member of the Institute of France. He is an honorary LL.D. of Glasgow and of Birmingham, also an honorary D.Sc. of Dublin, Oxford, Cambridge and Liverpool, Columbia, likewise Ph.D. of Tübingen and Krakau, M.D. of Heidelberg and Jena, and was created K.C.B. in 1902.

He divided with Lord Rayleigh the Hodgkins prize of $10,000 offered by the Smithsonian Institution of Washington, D. C., as well as the Lecompte prize of 50,000 francs awarded by the Paris Académie des Sciences, and he has besides received the Barnard medal of the American Academy, the Davy medal of the English Royal Society, the Longstaff medal of the English Chemical Society, the Le Blanc medal of the French Chemical Society, and the Hofmann medal of the German Chemical Society in addition to the great Nobel prize for chemistry in 1894.

Nearly all leading English and foreign scientific publications have at different periods received contributions from him and he is also the author of three textbooks on chemistry and of numerous other separate works, of which the most important are: "Argon, a new constituent of the atmosphere," "Atomic volumes," "The critical state of gases," "Helium, a constituent of certain minerals," "Neon, krypton and xenon, three new atmospheric gases," "The discovery of the constituents of air," "The gases of the atmosphere, the history of their discovery" (third edition, 1905), "Experimental proofs of chemical theory," "System of inorganic chemistry," "Position of argon and helium among the elements." Sir William is likewise the author of a translation of a paper by the well-known chemist van't Hoff treating of the nature of solutions which attracted world-wide attention, and, during the year 1908, he published a volume of biographical and chemical essays most of which had been delivered as lectures or published as magazine articles during the previous twenty-five years. The Chemical Essays treat of the early days of chemistry and cover the Becquerel, Radium, and other investigations and the Biographical Essays embrace full accounts of Boyle, Cavendish, Davy, Graham, Jos. Black, Lord Kelvin and M. Berthelot.

As a teacher Sir William Ramsay has been no less successful than in the pursuit of scientific research, and his personality, his enthusiasm, have left a strong impression on all those who have been fortunate enough to be counted among his pupils.

The Effect of Fillers in the Manufacture of Soaps.

Some New Ingredients Recently Introduced.

By S. M. Bose.

In the soap industry any material used in addition to the alkali and fat required to make the soap proper is termed a "filler." Such fillers may be added either to cheapen the cost of manufacture or for various other purposes. They may be divided into the following classes:

1. Materials adapted to improve the activity of the soap; such are ammonium, sodium and potassium salts, glycerol, alcohol and turpentine oil.
2. Materials added for special purposes, such as bleaching and softening; among these may be mentioned borax, sodium phosphate, phenol, silicic acid and various bleaching agents.
3. Fillers in the narrower sense, whose principal function is to simply cheapen the product; among these are mineral soap stock, silicate of soda, talc and starch.

The most important fillers in general use are soda ash and sodium silicate. Soda ash is supposed to have been first used in soap by Van Haagen of Philadelphia shortly after the Civil War. Sodium silicate as a soap filler was first used by Christopher Thomas & Bros. of Bristol, England, in 1856, its use being officially and publicly recognized in 1862.

Sodium silicate.—A reasonable use of solutions of soda ash and sodium silicate would generally improve the quality of a laundry soap. They make the soap more durable by the crystallization of the salts and prevent the rapid drying of the soap. "Its chief effect (i. e., of sodium silicate) on soap is to harden it on aging, to reduce the tendency of alkaline salts to effloresce, and to a certain degree to overcome the sticky feeling common to rosined soap. While mixing well with soap itself it aids in the incorporation of other material. Its detergent effect in soap is slight if any when the latter is fresh; but on aging its effect is to reduce the detergency of soap. It tends to increase the smoothness and gloss of settle soap and to destroy the natural texture." (Lamborn). Sodium silicate can be used only in the cheapest of

domestic soaps as it makes them strongly caustic. It also makes the soap wasteful in water. It is used also in settled rosined soap from 25 to 50 pounds per frame and in the cold process soap up to 100 per cent of the weight of glyceride stock. When sodium silicate is used in large amount in cold process soap, additional lye should be used above that required for the fat to neutralize the silicate. The common practice is to add lye and silicate successively to the fat.

The salicylic acid and phenol are used as disinfectants in soap. Soda crystals (washing soda) are sometimes used in soap to the extent of 5 per cent; any excess will cause a white saline efflorescence on the surface of the soap, and make the soap very wasteful in use. It however cheapens the product and adds to its detergent property. It also softens hard water and thus saves some soap.

Borax possesses valuable detergent properties and can be used with better results instead of the more strongly alkaline carbonate of soda. It is slightly alkaline and has some bleaching effects.

Petroleum jelly or mineral soap stock, a by-product in the manufacture of paraffin, is a mixture of hydrocarbons. It makes the soap more pasty and gives some binding power to soap that tends to "open." It has no other useful property and can be regarded as an adulterant, and is much used in America to cheapen soaps.

Talc is an inert filler used in cheap laundry soaps, soap powder and in milled toilet soaps. It increases the weight and has no useful property at all. It gives a smooth product, as the substance itself has a soapy feeling, and can be used to the extent of 5 to 10 per cent, increasing the weight of the soap by its hygroscopic property. It may be regarded also as a simple but harmless adulterant.

Pearl ash (carbonate of potash) is used to harden soaps and gives them a finer texture, which is achieved by a double decomposition between the soap and the pearl ash, resulting in the formation of a potash soap and Na_2CO_3 (sodium carbonate). The former makes the soap smoother and more transparent and the latter hardens it. Too much pearl ash would make the soap pasty.

Fullers earth has been used for cleaning purposes from the earliest times, and was the soap of the ancient Romans of the time of Pliny. Spent Fullers earth which has been used in deodorizing and decoloring substances of an oily or fatty nature (e. g., cotton seed oil) can be used most advantageously in the manufacture of soaps as a filler. In such soaps it acts as a scourer and can be specially used in household and family soaps.

Substances rich in protein such as various kinds of Oriental beans and lentils (powdered), maize, bran, etc., have peculiar cleansing properties of their own and are much used by Oriental women in remote places where soap is still regarded as a luxury. From time immemorial powders of such protein-containing substances have been used by the women of the Orient for their bath, just as soap is use by their Western sisters. It seems that protein-containing substances have an emollient effect on the skin, and it is interesting to note that fresh sweet cheese is used for this purpose by mothers in India to give softness to the skin of their young daughters.

Such protein-containing substances, when treated with concentrated lye, produce thick glutinous bodies possessing detergent properties and can be used as soap ingredients. The idea of doing this first struck me while I was visiting a soap factory in Japan about five years ago. In the factory in question they were adulterating the soap at the time of crutching with bran and similar powders, to cheapen the product, and perhaps also for the sake of the softening influence of these materials on the skin. But the soaps produced were of poor quality and the adulterants were not properly incorporated in the body of the soap.

For protein-containing substances I used casein (both the commercial variety and that made by me in the laboratory), heart of wheat, wheat middling, shorts, bran—the last three being the offals from a flour mill—and beet pulp. They were treated with concentrated lye of 45 deg. B. A cold process lard soap was made from each of these substances. This alkaline substance was thoroughly mixed with the lard, and the requisite amount of lye for complete saponification was added and the mass stirred continuously, until it began to thicken when it was ready for plodding. The advantage of this method is that in a little over an hour the saponification is complete and the soap is ready for plodding and can be made into bars or tablets. There is much saving of fuel, as the ingredients are used at ordinary temperatures and the saponification is completed by its own heat of reaction. The percentage of lye needed is best determined by the Koettstorfer test. The lye is best used at 36 deg. B., and the temperature of the room. The lard should be at its temperature of fluidity.

Cocoanut oil, tallow, palm oil, and castor oil all make a better soap by this process than by the purely cold process, being used at their melting temperatures, to allow thorough mixing. When cocoanut oil is used this will be 80 deg. to 90 deg. Fahr., with a mixture of cocoanut oil and tallow about 100 deg. Fahr., with tallow about 110 deg. Fahr. The temperature should not exceed or be less than that indicated above, as with a high temperature saponification ensues immediately on mixing and particles of soap will inclose fat and lye and remain distributed throughout the mass, being then difficult to disintegrate. With stock containing fatty acids this tendency is noticeable, hence as low a temperature as would keep the stock fluid is all that is necessary.

The way in which the alkaline substances are mixed also has some effect on the soap. The best practice seems to be to mix all the requisite lye with the alkaline substance, mixing this with the stock in a slow stream and thoroughly stirring. Adding the alkaline substance first and then adding the rest of the lye also gives good results.

Alkaline stock.—The beet pulp should be dried and powdered to avoid excess of water. For a cheap domestic soap the use of beet pulp and the wheat products may be recommended. Two or three of these alkaline substances may be mixed with advantage. The alkaline stock improves with long standing. With casein a good quality of toilet soaps can be made, with superior emollient and cleansing properties. The alkaline casein gives out appreciable amounts of ammonia, and according to Hauser (*Vide Chemisches Zentralblatt*, 1909—II, 1503) the presence of free ammonia gives a better emulsification than ordinary soap solution, and will thus increase its cleansing value. The casein also has a softening influence on the skin.

Advantages of the method.—These alkaline stocks are better than fillers as they can be regarded as ingredients of soap; having detergent values of their own and being in a state of chemical combination with the lye they undergo a thorough incorporation in the soap, unlike the other fillers, which are more or less mechanically combined. The detergent value of the soap is not diminished, and the process has the advantage of allowing a very thorough and complete saponification. Moreover no extra heat is required and there is thus a great saving of time, labor, fuel and expense. The operation may be completed in a little over an hour.

Detergency.—I made a sample of lard soap with lard and lye and compared the detergent values of the various samples with it, and found the values did not deteriorate with the addition of the alkaline stocks. The detergent value was determined by Pon's process. There was a lowering of the value in the case of the beet pulp, owing perhaps to the excess of its water contents. The cleansing value was also determined by another rough method. Some lampblack and turpentine was diluted in gasoline and a number of pieces of cloth of a definite size were immersed in it. These were afterward washed with the equal amounts of each of the soaps, under identical conditions of time, temperature and water. The casein soap and the one with the heart of wheat, seemed to show higher cleansing value—the casein soap more so than the other, which shows its greater cleansing value. It is also important to note that a 0.3 to 0.4 per cent solution gives a better washing value.

Some Important Notes.—In the cold process, a proportion of potash improves the product in a noticeable degree, rendering the soap milder and better in appearance.

The fatty acid salts of fatty acids with low melting point have the maximum emulsifying power at ordinary temperature, and so soaps made of these should be used in the cold. Soaps containing a large amount of palmitic and stearic acids are best for use with heat.

The use of a bleaching material such as perborate in the soap increases its cleansing power.

Detergent Power of Soap.—Mr. W. Spring in his exhaustive series of researches on the detersive action of soap solutions, conducted at the Institut de chimie general de Liege (in 1910), gives the following explanation:

"The cleansing power exercised by soap is due to the substitution of soap in the soiled object. The affinity of the soap for the dirt removes the latter by overcoming its affinity for the soiled object; that is to say, the dirt forms with the soap a colloidal absorption compound more stable than that which it forms with the soiled object. This has been proved by the action of soap on lamp black. Lamp black in suspension in pure water forms a more or less stable absorption compound with solid bodies, more especially celluloid. Thus, for instance, a filter paper absorbs all the black from such suspension, and if the filtrate is returned over it, the water will not remove any of the combined lamp black. On the contrary, lamp black in suspension in soap water forms a stable combination with the soap and then passes through the filter paper without blackening it.

The "Notes de Chimie" (April, 1909, page 794) gave the summarized results of the action of soap on lamp black, and Mr. W. Spring concluded that the cleansing of an object with soap is nothing more than the phenomenon of substituting soap in this object; the colloidal combination of carbon, soap not possessing the faculty of attaching itself by absorption to solid bodies and is easily removed by water.

If this theory be correct, it is evident that whatever is used in the making of a soap should be completely soluble in water without much delay, to give it the highest possible cleansing value, and any insoluble or difficultly soluble substance in the soap will tend to hold the dirt. The alkaline substances used are all readily and completely soluble in water in their changed form and hence they can be used with advantage.

Japanese Writing Accessories

The art of calligraphy came to Japan from Korea with the introduction of Chinese characters early in the Christian era, its first historical mention belonging to the beginning of the fifth century. But although all the writing material was imported from the land which gave them the art, the Japanese soon learned to make for themselves the brushes and inks. The former (fude) are made in different qualities and are of three different sizes, for ordinary writing, for large writing and for sign writing. The length of the hairs varies from one-half inch to five inches, but they are always tapering into a fine point at the end. Those used for the old school painting are two inches long and have so few hairs that these may readily be counted. The handles are in most cases made of bamboo, as this is a light and convenient material, but in some cases red sandal wood, ebony or other Indian wood, as well as ivory is employed. The hair of rabbits, weasels, deer, badgers and sables is used for the brush end in Japan; in China hair of rats and tigers is greatly prized for that purpose. Ordinary writing brushes sell for two to ten cents, although sometimes expensive ones are made to order for writing experts. Celebrated writers have kept their old brushes instead of throwing them away and buried the collection with some ceremony.

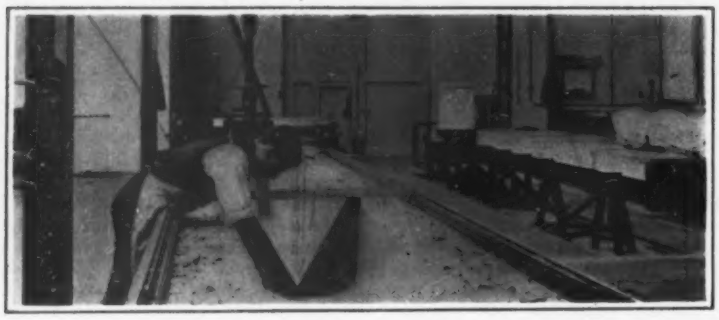
The ink (sumi), like the Chinese ink, is made in sticks, and when about to be used is rubbed upon a stone with water to the consistency desired. There are two kinds of ink, one made from pine soot, the other from oil soot, the latter being favored. Pine soot ink is made as follows: Two rows of furnaces are installed under a shed, about sixty by eighteen feet. These furnaces are completely covered by paper screens, except for the openings. Pine branches which have been selected as having a large amount of resin are burned in the furnaces continually for six days, when the screens are coated inside with soot, which is removed by bird wing brooms and put through a sieve of extremely fine mesh. They are then mixed with glue, placed in molds and pressed. Oil soot is made in a smaller shed, three sides of which are covered with rows of shelves. Upon these are placed earthenware vessels, each containing oil and a wick, which is lighted, and over it an earthenware bowl is inverted, so as to be within two inches of the wick. Soot collects on this cover and is removed and made into ink as stated above. The ink sticks are usually three to five inches long and one to two inches wide, although much smaller ones are made. The average price is seventy-five cents apiece; the smallest ones are sold for five cents, while the best of the largest size sticks are worth as much as two and three dollars. Red ink is made of cinnabar, also in sticks and used in the same manner as black ink. Chinese ink is said to improve in quality with age and is not subject to the chemical changes which Western writing fluid undergoes.

Ink stones for grinding the ink ready for use are from two to twelve inches wide and one-half inch to three inches thick and are either round, square, oval or rectangular in shape. The depth of the portion hollowed to receive the water poured upon the stone for grinding and mixing the ink varies in accordance with the size of the stone. Covers for the stone are made of fine art wood and sometimes odd and even grotesque shapes are followed. The best material for the stones is found in the Wakasa Province and is of a deep purple color; the next in quality is from Nagato Province, being purple or green; the third grade is a reddish stone from the Province Harima. Sometimes old tiles are used and converted into ink stones.

These writing accessories are indispensable household articles, and are to be had from the simplest and most inexpensive kind to the finest and choicest article of rare material and artistic design. Most Japanese still adhere to this ancient mode of writing with brush and ink, although the use of pen and writing fluid is common in the schools and among students.—*Japan Magazine.*

Old Cedar Wood for Lead Pencils

Pencil manufacturers have been buying old cedar rails and cedar boards from the old barns of the farmers for the reason that such wood having been exposed for many years to the elements, is in far better condition than new cedar. The latter carries a large amount of resinous matter and it is difficult and expensive to get rid of this. When not thoroughly eliminated, it tends to warp the pencils and to ooze out, marring, if not destroying the finish.—*Shanghai National Review.*



Making a Clay Model in which the Wax Ship is to be Cast.

Tanks and Models Used for Investigating the Causes of Collision.

The Hawke-Olympic Collision

Suction Between Ships Passing at Close Quarters

By Percy A. Hislam

Tank and Hose for Pouring Melted Wax in Making Ships' Models.

The litigation arising out of the collision on September 20th last between the White Star liner "Olympic" and the British protected cruiser "Hawke" is not yet finished. At the first hearing the British Admiralty Court decided that the liner was entirely to blame, but that as her owners were compelled to carry a pilot through the waters in which the accident happened they were not liable to damages. The White Star Company has, however, decided to appeal against the decision of the court, so that the whole affair is really still *sub judice*. Meantime, the British naval authorities have expressed their approval of everything done by the commander of the "Hawke" (William Frederick Blunt) by promoting him from the rank of commander to that of captain.

The collision, and the subsequent hearing in the Admiralty Court, were of exceptional interest on account of the position occupied in the mercantile world by the "Olympic." She was practically a new ship, and the largest liner in existence, with a gross tonnage of 45,000, a length of 888½ feet, a beam of 92½ feet, and a combination of turbine and reciprocating engines equal to 59,000 indicated horse-power. Her draft at the time of the collision was 33½ feet forward and 34 feet aft, and her displacement in sea water 50,500 tons. In the words of the president of the Admiralty Division (Sir Samuel Evans), she was "a veritable leviathan, that maketh the deep to boil like a pot." The "Hawke," on the other hand, is one of the oldest protected cruisers in the British navy, having been launched in 1891 and long ago relegated to the reserve. She is 360 feet long, 60 feet in beam, and displaces 7,600 tons, her engines being of 10,000 horse-power.

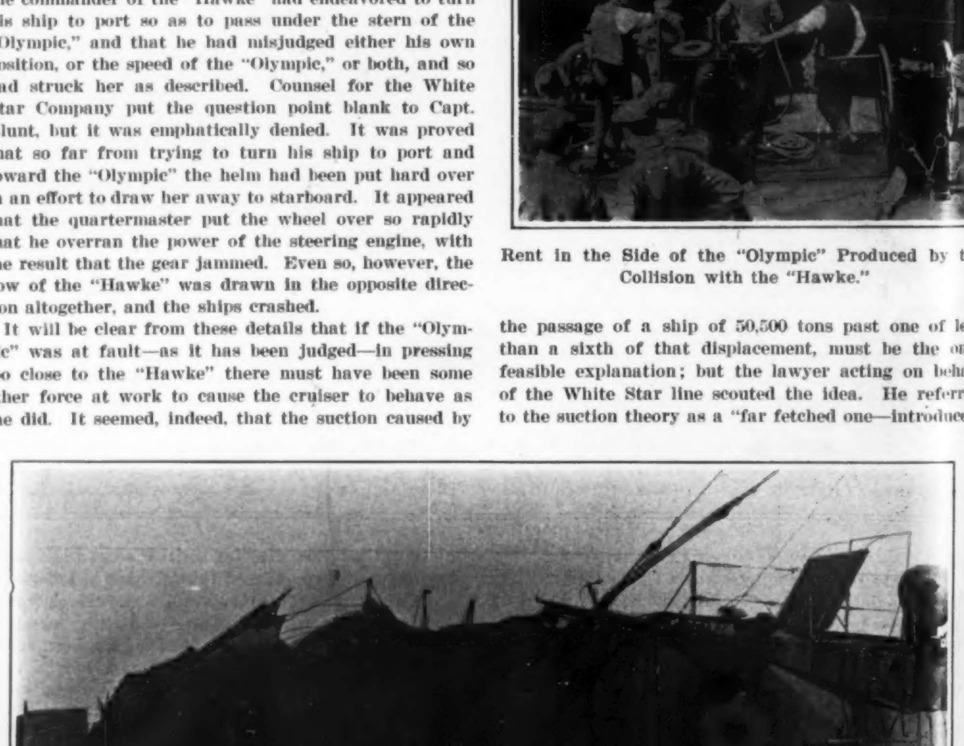
It is not proposed here to give a full account of the accident and of all the movements of each ship that led up to it. The "Olympic" had just left Southampton westward bound to New York, while the "Hawke" had been carrying out a periodical power-trial of her machinery. While in one of the comparatively narrow and shelf-bottomed channels behind the Isle of Wight leading into the English Channel the two ships found themselves on parallel courses, and, according to the evidence on which the court based its judgment the "Olympic," which was the faster vessel and so ought to have kept clear of the cruiser, forced that vessel on to the edge of the navigable channel. This process of "pinching" was carried so far that at last the commander of the "Hawke" found himself compelled to alter his helm so as to get still farther toward the edge; but by that time the ships were so close together that the "Hawke" not only refused to answer her helm, but took a rapid sweep toward the side of the "Olympic" and, with velocity increasing as she approached, rammed her almost at right angles, her spur ram tearing a hole in the liner's side about 85 feet from the stern and penetrating to a distance of eight feet. At the moment when the "Hawke" swung her bows round toward the liner the distance between the ships was about 100 yards.

The conclusion to which most people came was that the commander of the "Hawke" had endeavored to turn his ship to port so as to pass under the stern of the "Olympic," and that he had misjudged either his own position, or the speed of the "Olympic," or both, and so had struck her as described. Counsel for the White Star Company put the question point blank to Capt. Blunt, but it was emphatically denied. It was proved that so far from trying to turn his ship to port and toward the "Olympic" the helm had been put hard over in an effort to draw her away to starboard. It appeared that the quartermaster put the wheel over so rapidly that he overran the power of the steering engine, with the result that the gear jammed. Even so, however, the bow of the "Hawke" was drawn in the opposite direction altogether, and the ships crashed.

It will be clear from these details that if the "Olympic" was at fault—as it has been judged—in pressing too close to the "Hawke" there must have been some other force at work to cause the cruiser to behave as she did. It seemed, indeed, that the suction caused by

Rent in the Side of the "Olympic" Produced by the Collision with the "Hawke."

the passage of a ship of 50,500 tons past one of less than a sixth of that displacement, must be the only feasible explanation; but the lawyer acting on behalf of the White Star line scouted the idea. He referred to the suction theory as a "far fetched one—introduced



View of the Battered Bow of the Warship "Hawke."

in fact, from so far away as Washington," and declared that he relied upon a number of witnesses of high standing in the shipping world, who had never heard of suction at all.

In the result, however, suction has been held to be one of the principal causes of the accident, through the fault of the "Olympic's" pilot in taking his ship near enough to the "Hawke" to allow the force to come into play. In the course of his evidence the pilot declared that it would be perfectly safe to pass within 100 yards of the "Hawke" with the "Olympic" running, as she was at the time, practically at full speed; but as, when asked if he knew "anything about suction" he said "No," his assertion cannot be accepted as it stands. As a matter of fact, it was conclusively proved that suction is a very powerful force to be reckoned with, and that it is greatly increased in effect under such conditions as existed at the time of the collision, that is to say, a large ship passing a smaller one at high speed and within a comparatively short distance, and over a shallow and shelving bottom.

In order to put the suction theory to a practical test a series of experiments were carried out at the National Physical Laboratory at Teddington. The tank at the laboratory was presented by Mr. Yarrow, of the well known firm of torpedo-craft builders, and is maintained by public subscription. Models of the "Olympic" and "Hawke" were made in wax by the use of the lines available, and the tank was specially prepared to represent the conditions as to channels and bottom generally which exist where the collision occurred. The "Olympic" model was operated by a small motor to work the screws, and the two models were towed on parallel courses at speeds corresponding with those at which the ships were supposed to be traveling on September 20th. Nine experiments were made in the presence of the president of the court and others immediately interested, including the Masters of Trinity House. In the first experiment the "Hawke" swerved in very badly toward the "Olympic." In the second the helm of the "Hawke" was put over 20 degrees, which should have been ample to take her away from the liner model, but instead she swerved in toward it.

In order to support their theory of suction the British Admiralty secured the attendance of Naval Constructor David Watson Taylor, of the United States Navy, well known as an expert in this branch of the theory and practice of navigation. His evidence was looked forward to with much interest, and this was certainly justified. He declared that, assuming the position of the two ships before the collision to be as described by Admiralty witnesses, and that the lateral intervening distance was 100 yards, the "vessels would develop a strong suction tending to draw the bow of the 'Hawke' toward the 'Olympic.' The sheering of the 'Hawke's' bow would be against the helm, and would rapidly become irresistible, so that no hard-to-port helm of 35 degrees could stop it." Constructor Taylor further stated his opinion that in the conditions existing at the scene of the collision it would have been impossible for the "Hawke" to overtake and pass the "Olympic"—even if she had been the faster ship—at a distance of 100 yards. "I should say," said Constructor Taylor, "the tendency to sheer in as she got up toward the 'Olympic' would become stronger and stronger, and in my view she would not be able to get her stem abreast of the center of the 'Olympic.' She would fast get into the position of the maximum sheering tendency." He was fully supported in this view by Prof. Biles, professor of Naval Architecture at Glasgow University, and by Prof. Walsh, who holds a similar position at the University of Durham.

As already stated, counsel acting for the owners of the "Olympic" scouted the idea of suction, and it was certainly surprising that he could find so many professional seamen to support him. The captain of the liner, asked if it was likely that suction would have come into operation at a distance of 100 yards, replied: "I don't know anything about it, but it might do so." The "Olympic's" pilot, as already recorded, declared he knew nothing about suction. Various subordinate officers of the "Olympic" were equally ignorant, and the captain of the "Mauretania," called in as witness, declared that in all his career he had never come across suction, or interaction between vessels. There is no doubt that the peculiar condition of the bottom at the scene of the accident contributed very largely toward increasing the sheering tendency of the "Hawke," which, traveling in shallow water, naturally tended toward the adjacent deep water. At the same time, it is obvious that there is a great deal to be learned as to the inter-action of ships, whether by suction, by displacement of water, such as occurs when ships pass in a narrow canal, or by the action of propellers on the adjacent ship's rudder. The engineer officer of the "Hawke" gave it as his opinion that the swerving of the ship was caused more by the action of the "Olympic's" screws on the cruiser's rudder than by pure suction. In any case, there appears to be a wide and profitable field for investigation, particularly as suction force must rapidly increase with the growing size and speed of ships.

Precious Stones in 1911*

A Vast Industry Dependent on a Demand for a Luxury

By George F. Kunz

It seems remarkable that in the face of a universal financial depression the price of diamonds and pearls should have advanced considerably since 1906, and this after only one year's shutdown of the great group of diamond mines and with no attempt to regulate the price of pearls. The imports of precious stones have remained constant, for, although the imports in 1908 were less than in 1906, a banner year, this was partly the result of overbuying, and the effect of the small importation in 1908 was the selling down of the old stocks, which in turn led to the greater imports of 1909, 1910 and 1911.

That the sale of precious stones does not always fluctuate with financial conditions was never more apparent than this year, which was marked by a financial slump in September, by threatening war clouds between Germany and France, Russia and Japan, by the revolution in China, and, finally, by the war between Italy and Turkey. But it will invariably happen that when people are assured of the permanent worth of an investment they will not hesitate to buy even when the financial situation appears to be less favorable than usual, or else they buy because they will buy under all circumstances.

STEADY ADVANCE IN DIAMOND PRICES.

However, the upward trend of prices, especially that of the diamond output, has steadily continued, in spite of occasional setbacks; this is clearly apparent when we compare the average prices of the uncut, rough diamonds for five-year periods for the last twenty years: 1891 to 1895, average price per carat, 26s. 9.45d.; 1896 to 1900, 29s. 1.15d. per carat, increase in price, 8.6 per cent; 1901 to 1905, 47s. 3.36d. per carat, increase, 62.5 per cent; 1906 to 1910, 55s. 7.93d. per carat, increase, 17.7 per cent. The diamond syndicate advances on the price of rough diamonds when sold to the diamond cutters have been as follows: June, 1906, 4 per cent; May, 1907, 3 per cent; June, 1909, 5 per cent; June, 1910, 2 per cent.

GREATER COST OF DE BEERS DIAMONDS.

That the advances in diamonds are justifiable may be seen after a study of the report of the De Beers Consolidated Mines for the year ended June 30th, 1911. The amount of production was £4,938,086, the total revenue being £5,928,830. Deducting from this £2,930,213 for mining expenses, depreciation, interest on debentures, etc., there remained a balance of £2,998,616. From this £310,137 was paid to the Union of South Africa for taxes on profits for the year ended June 30th, 1910, and £265,458 was set aside to cover the taxes on profits to June 30th, 1911. This shows the increased cost of mining at greater depth. Preferred dividends to the amount of £800,000 and deferred dividends amounting to £1,000,000 were paid and provided for. After subtracting these items there remained a balance of £623,019 on the year's operations. On January 1, 1911, the balance of the first mortgage debentures of the company, bearing interest at 5 per cent, to the amount of £1,216,120 were redeemed, as were also £27,080 of Bultfontein obligations at 4½ per cent. The reserve fund was increased from £968,905 to £1,374,766 during the year, and the company was relieved of a contingent liability of £630,000 for the Klerksdrop-Fourteen-Streams Railway Company by the Union government's settlement of that company's debentures.

The following average results were attained in the different mines of the De Beers group during the year ended June 30th, 1911:

	Carats per Load.	Value per Carat.	Value per Load.
De Beers & Kimberley	.28	51s 6.29d	14s 5.12 d
Wesselton	.27	37s 9.6 d	10s 2.47 d
Bultfontein	.38	35s 0.52d	13s 3.79 d
Dutoitspan	.21	73s 6.5 d	15s 5.325d

At the same time even with the advances in the price there was a decrease of £476,800 in income as compared with 1910, due to the decreased production, although the price rose steadily. This decrease represents fully one half the amount of the value of the German Southwest Africa deposits, and with the increased demand all over the world, a larger diamond yield would not glut the market and continued advances are not improbable, clearly proving that the bourses do not always dictate the prices of commodities which have an international status.

The value of the precious stones, cut and uncut, brought into the port of New York in 1911, the figures for December being estimated, is about $40,854,088, as against $40,566,489 for 1910, thus showing a slight increase in the imports of these articles. As the conditions prevailing during the year were distinctly unfavorable, it is evident that under normal conditions there would have been a considerable increase over the figures of the previous year. As it is, only in the record year of 1906 were more precious stones imported into New York than in 1911, the difference between these two years being $2,719,400 only.

The total importations into the United States for ten months of 1911 are, from official figures, $36,413,685, and the amount for the whole year may safely be put at about $42,500,000. This would be about $1,000,000 less than in 1909, $1,750,000 less than in 1906, and a small increase over the figures for 1910. It is noteworthy that in no triennial period were so many precious stones imported into our country as in the years 1909, 1910 and 1911, during which time precious stones worth nearly $128,500,000 were brought in. The nearest approximation of these figures was in 1905, 1906 and 1907, when the imports totaled $114,306,458.

DE BEERS PRODUCTION TO DATE 67,000,000 CARATS.

We can gain some idea of the enormous production of diamonds in the South African fields from the fact that the De Beers group of mines has furnished diamonds weighing at least 67,000,000 carats and worth more than £100,000,000, or $500,000,000. If to this immense sum we add the value of the diamonds extracted from the Premier mine, from a number of smaller independent mines and from those in German Southwest Africa, we would probably have a total of nearly, if not quite, $600,000,000. The great and consistent demand for diamonds is strikingly shown by the rising prices, notwithstanding this enormous production. Before these reach the final customer, when all the costs of cutting and handling are added, the value will amount to about $1,200,000,000.

When we consider that in 1906 the German-African mines had not yet been developed, and that there has been an average annual yield of about $4,500,000 from this source during the last three years, in addition to the South African supply, it is not surprising that the diamond mines of New South Wales should receive the encouragement they do. However, there is as yet considerable doubt as to the likelihood of their ever equaling the African mines in richness, or their ever becoming dividend-payers. There has not been any important development of the Arkansas deposits, which, in their present condition, are awaiting the placing of extensive machinery for working them. Some small diamonds have been found in the Belgian Congo at a point 1,500 miles north of the Kimberley mines, and there is only a nominal supply from British Guiana. The East Indian yield is less than £2,000, less than a day's African output, and the Brazilian not over £50,000 or about a week's output.

The diamond, the pearl, the emerald and the sapphire are now enjoying public favor to the full. There has been a material advance in the price of these gems from the figures of four years ago, when I predicted that the sapphire in particular, which had not been the subject of fashion's favor, was soon likely to become so.

The Fergus County, Mont., mines, were more productive than ever before; however, in general (and larger blue stones are included), colored stones are not so well favored as they were formerly.

Cameos, which have not been in vogue for over twenty years, are being revived to some extent, although not enough to enable the dealers to sell out their old stocks. Coral is now in great favor. Many necklaces are imported at a wide range of price, the cost varying from 5 cents to $2,000. Pearls are higher in value, this being due both to the decreasing fisheries and to the universally accepted edict that the pearl is one of the richest and at the same time one of the most modest of jewels; therefore the price has steadily advanced since 1895, notwithstanding the depressions of 1907 and 1910. One of the principal discoveries of gems was that by Schaller of turquoise in minute triclinic crystals in Campbell County, Virginia.

Two-thirds of all fine jewels are now mounted in platinum. Whether it is due to this demand or not, platinum, which sold at $18 per ounce in 1881, and at $24 in 1891, brings in 1911 over $50 per ounce when combined with 5 or 10 per cent of iridium.

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The Production and Identification of Artificial Gems—II*

How They Are Made and How Distinguished from the Real

By Noel Heaton, B.Sc., F.C.S.

Concluded from Supplement No. 1885, page 103.

It will, of course, be well understood that the experiments I have briefly indicated toward the artificial production of corundum had as their immediate objective the formation of ruby, that being by far the most valuable variety. It had long been known that the color of the ruby was due to a trace of chromium, and by adding a small proportion of potassium or ammonium chromate to their mixture, Fremy and Feil reproduced accurately the color of the ruby in their crystalline flakes.

The process of producing reconstructed rubies by means of the oxy-hydrogen blowpipe is, roughly, as follows: The residue from cutting rubies and small worthless stones is broken into coarse sand, a small quantity of which is placed on the center of a disk of platinum; this is then carefully brought to the fusion point, care being taken at this stage not to raise the temperature to such an extent as to melt the platinum support. As soon as this mass is fused it serves to protect the platinum, and the reconstructed ruby can be built up on it by adding the fragments of ruby one at a time by means of small platinum forceps. These pieces have to be dropped on with great care in order to secure incorporation with the mass and prevent as far as possible the formation of air bubbles. It will be readily understood that this process is a tedious and laborious one, and, in fact, the formation of masses of sufficient size to yield large stones on cutting is a matter of such difficulty that the cost of production is very high.

Just about seven years ago, however, Verneuil† overcame this restriction when he hit on the extremely ingenious idea of introducing the raw material through the blowpipe, and thus placing it on the support automatically. The diagram (Fig. 2) shows the principle of his apparatus. The blowpipe is arranged vertically over a small insulated chamber containing the support on which the mass is to be built up. The oxygen tube communicates at its upper extremity with a funnel-shaped hopper, in which is suspended a small sieve filled with raw material, which is rhythmically shaken by means of a small hammer actuated by an electro-magnet or cam. Each time the hammer taps the support of the sieve, causing it to vibrate, a small quantity of the powder falls through into the tube below, and, carried along by the gas, passes out at its lower extremity into the zone of flame, where it is immediately raised to the fusion point, and falls as a melted globule onto the support below.

As seen in the diagram, this support is arranged with a screw adjustment, so that as the mass of corundum is gradually built up by the constant addition of fresh globules the surface can be kept at a constant level, and the portion already formed removed from the zone of heating so as to allow it to stiffen. When the apparatus is first started the blowpipe is adjusted so as to give a comparatively cool flame, and the powder is admitted slowly. By this means a small "stalk" is formed, which insulates the mass from the support and prevents the fusion of the latter. When this has been formed the full pressure of the blowpipe is put on and the rate of admission increased, with the consequent formation of a "boule," as the pear-shaped mass produced is termed.

With this apparatus a boule weighing some twenty to thirty carats, and capable of yielding two cut stones of about six carats each, can be prepared in about half an hour almost automatically, a single operator being able to control several machines. The boules, on cooling, very often split in half in the direction of their growth, and this is a convenience rather than otherwise, as the resulting shape can be cut to greater advantage.

In the first instance reconstructed rubies were made in this way after the manner introduced by Gaudin, the material fed into the blowpipe being pulverized rubies and chips, and this method is still employed by some workers. But more commonly nowadays the corundum is produced direct from amorphous alumina by using pure ammonium alum as the raw material. On reaching the flame this decomposes, the ammonia and sulphuric acid volatilizing, leaving the alumina. Stones made by this process are generally known as "synthetic," as distinct from "reconstructed," although, of course, to the pedantic, the process is one of decomposition rather than one of absolute synthesis.

The "synthetic" corundum produced in this way, if pure ammonium alum is used, is, of course, colorless, and can be used as artificial white sapphire. If a small proportion of chrome alum is added, the resulting stones are rubies, and other colors may be produced in the same way. For a long time all attempts to reproduce the fine blue of the sapphire failed, because, following the apparent analogy of silicates, cobalt was invariably employed as the coloring agent. This, however, does not readily form an aluminate in the same way that it does a silicate, and, in consequence, it is impossible to produce a satisfactory coloration in the corundum by its means; it is possible to

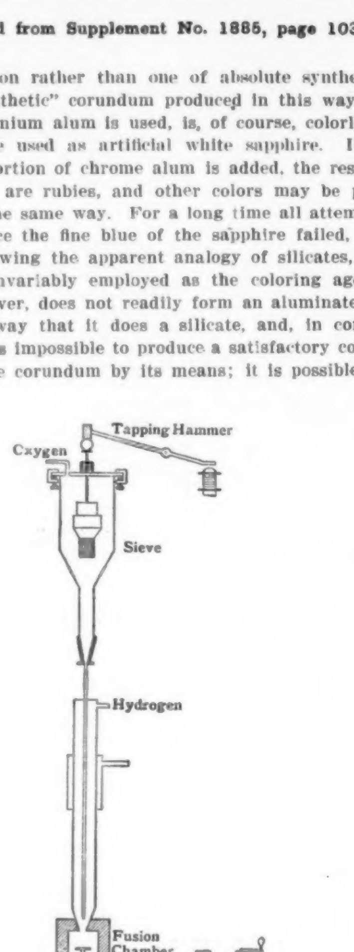


Fig. 2.—Apparatus for "Reconstructing" Rubies.

get the cobalt in a state of combination by adding a large proportion of magnesia to the alumina, but then the product formed is not a crystalline alumina but magnesium aluminate, and its properties are fundamentally different. Its refractive index is lower, its refraction single, and its hardness lower. In fact, the result is blue spinel instead of sapphire. Moreover, such blue stones have the characteristic absorption of cobalt, and appear purple in a light that does not contain a large proportion of blue rays.

In 1908 Paris attempted to avoid this latter difficulty by preparing a calcium aluminate colored with cobalt, as it is found that in this case the transmission of the red rays is less pronounced. But the calcium aluminate so formed is not crystalline at all, but amorphous. A year or so ago, however, the problem of producing synthetic sapphire was finally solved by the use of titanium oxide, a very unexpected result, considering the chemical position of this element. With this last advance the artificial production of the corundum gem-stone may be considered to be completely solved, and cut stones can now be obtained in every variety of color, from pure white to ruby and sapphire, at prices ranging from $1 to $2.50 a carat, according to color, quality and size.

Whatever may be their economic importance, a very much debated question, there can be no doubt as to the scientific interest of this group of artificial gems. In the first place it is a matter of some interest that a mass of fused material formed in this way should not only be crystalline but possess all the characteristics of a single crystal. Crystallographers are agreed that each boule is a single crystalline individual, with the axis roughly perpendicular to the plane of formation—that is to say, running from the point of attachment of the pedestal to the top of the mass. On the top of the boule one invariably finds a mass of symmetrically-arranged facets, which Dr. Herbert Smith has found to correspond with the fundamental rhombohedron of corundum. Judging by analogy with other materials, one would expect at first sight that a fused mass formed in this way would be either a heterogeneous mass of minute crystals, or entirely amorphous, possessing the structure characteristic of glass. It is well known, for example, that under similar conditions pure silica yields "quartz glass," which is extensively manufactured at the present time.

Then, again, there is the matter of coloration. One would like very much to know what is the state of combination of the chromium in a ruby, and whether the color is produced by chromium aluminate in solution or metallic chromium in molecular suspension. In glass, as is now well established, this color is produced by the optical effect of ultra-microscopic spheres of metallic gold or copper, but there seems to be no parallel between the two cases.

A point of more practical interest is the fact that although the artificial corundum is a true crystal it possesses the shape and formation of a congealed liquid or glass. The practical interest of this lies in the fact that it affords the only means of distinction between this artificial corundum and the naturally-formed gem-stone. Being of exactly the same composition and crystalline structure as the natural mineral, it cannot be identified by any of the physical tests I briefly referred to above. For all practical purposes the artificial ruby *is a ruby*, and one can only deny that it is a "genuine ruby" if this word is held to connote essentially a product found in the earth and not made by man.

And yet, owing to the curious anomaly of its structure, the artificial product can almost invariably be distinguished from the natural with the greatest ease. In the naturally-formed stone any foreign matter which may be present is coerced into following the lines of growth of the crystal, and more particularly bubbles of gas which may be present in the liquid are distorted from their natural shape so as to accord with this symmetrical growth. It is the great exception to find a natural ruby entirely free from such inclusions, which generally form irregular cavities with a decided tendency to geometrical shape.

It is very common also to find the structure technically known as "silk" caused by microscopic bubbles drawn out into a series of parallel canals, all lying in one plane. Any variation of color in different portions of the stone also follows the lines of growth in this manner.

In the artificially-produced corundum, on the other hand, although the particles arrange themselves symmetrically, any air bubbles that are entangled in the successive globules remain undisturbed, and appear as naturally spherical bubbles in the finished product; and, moreover, if one globule differs slightly from another in the proportion of chromium, the resulting difference in color follows the form of the mass as a whole, the zones of color being circular.

As some of the air entangled between the fine particles fed into the blowpipe almost invariably fails to make its escape during the brief fusion, the presence and form of the bubbles is in this way sufficient to identify the artificial process of formation.

In the great majority of cases examination of the cut stone with a lens is sufficient to decide the point, but in doubtful cases a more minute examination may be made by placing the stone in a little cell filled with highly-refracting liquid, in order to secure regular illumination, and examining it under the microscope by transmitted light, when the minutest trace of structure can be detected. In the case of an absolutely flawless stone it would be impossible to decide whether it were natural or artificial, but such stones are so rare that this case is almost theoretical.

It is claimed in some quarters, it is true, that "experts" can invariably distinguish the artificial product merely by reference to the color, which is said never to be exactly the same as that of the natural stone,

* Paper read before the Royal Society of Arts.

† "Mémoire sur la reproduction artificielle du rubis par fusion," M. A. Verneuil, *Annales de Chimie et de Physique*, Sept., 1904.

much as this latter varies. Personally, however, I am rather sceptical on this point, as one knows that experts claim in a similar manner to distinguish between one species of natural gem-stone and another by color alone, and their results are not *always* in accordance with scientific tests. At any rate such dexterity can only be acquired by a life-time of specialized experience.

As I have already indicated, spinels may be produced artificially by the same process as corundum, adding the necessary magnesia to the alumina, and the same remarks apply to the production and identification of this species as to corundum, the artificial stone being identical with the natural in all respects except those to which I have just referred.

As regards the remaining transparent gem-stones, which fall into a group by reason of the fact that they contain silica as an essential component, their artificial production is of little importance. They cannot be produced by the same process as corundum, owing to the fact, already alluded to, that under such conditions both pure silica and compound silicates yield an amorphous product, which has not the optical properties of the natural stone. One is constrained, for the artificial production of the crystalline material, to fall back upon methods similar to those employed in the earlier attempts to obtain ruby—obtaining the requisite composition by chemical reaction and maintaining the mass at a temperature just above its fusion point for a sufficient time to allow the silicate to crystallize out.

Topaz, garnets, and zircon have been produced in this way experimentally as a matter of scientific interest, but the small stones produced have no commercial value. The majority of these stones are of such common occurrence in nature, and consequently of such little value, that their artificial production in this manner is not a commercial proposition.

An exception, however, must be made in the case of the emerald, which ranks next to value to corundum, and many attempts have been made to produce it artificially. Reconstructed emeralds have been made by the Verneuil process, but these are, of course, amorphous, and do not possess the double refraction and other properties consequent upon the crystalline structure of the natural stone. The problem of producing this stone artificially has not as yet been solved in fact. I am quite aware in saying this that recent newspaper reports lead one to believe otherwise, but, as in the case of the diamond, such reports indicate either remarkable foresight on the part of the writers or show that their imagination is developed at the expense of their powers of accurate observation.

There remain now to be considered those precious stones which are opaque, and owe their beauty entirely to color and structure.

Turquoise is a stone formed under conditions which are easy to reproduce, and its artificial production was successfully accomplished, many years ago, by precipitating hydrated phosphate of aluminium with the requisite proportion of copper phosphate to give it the color, and subjecting the precipitate while still damp to hydraulic pressure for a considerable time. Prepared in this way the artificial turquoise is so nearly identical with the natural that its identification is a matter of considerable difficulty. There is, however, generally a slight difference in the specific gravity, hardness, and index of refraction (when this can be measured), which will serve to distinguish it on careful examination. The only point in which there is any decided difference between the two is the behavior on heating, but as this involves the destruction of the stone it cannot be offered as a practical test.

Opal consists essentially of what is known as colloid silica, that is, silica in the amorphous state and combined with water. The play of color one associates with it is entirely an optical effect, due to an accidental structure of the stone, which is permeated by a number of minute fissures, between which a thin film of air penetrates, the extreme thinness of this film causing the optical effect known as interference. If a piece of opal is powdered it is no longer colored, as would be the case with a ruby or sapphire, but yields a dirty white powder, and generally a specimen of opal, as found, only shows the structure in parts, the remainder being dull and lusterless like flint.

This peculiar structure is, moreover, by no means confined to opal, but may occur in any mineral deposited under similar conditions. In the mineral known as Lumachello, or fire-marble, for example, the same effect is seen in a lime-stone. But opal is the only mineral which combines this structure with sufficient durability for use as a gem-stone, and in this connection it should be remembered that, as a matter of fact, it only just possesses sufficient hardness for this purpose, and is one of the softest and least durable of all the precious stones. This fact, combined with the fragility consequent upon its structure, has involved the opal in a mass of superstition and romance from time immemorial.

Although it has this unfortunate drawback, opal is, at any rate in my estimation, the most beautiful of the precious stones, and when one appreciates the reason of its beauty it will be readily understood that its artificial production, or even successful imitation, presents almost insuperable difficulties.

It is true that a somewhat similar play of color can be imparted to glass by rendering it translucent by a slight addition of arsenic or tin in the making, and by etching the surface in various ways, and such iridescent glasses are often found naturally as the result of decomposition, but this is merely a surface effect, and such specimens cannot be cut to advantage; moreover, they lack the beauty caused by the fire permeating the entire substance of the gem. The opal ranks with the diamond, therefore, in resisting attempts at artificial production, and is even superior to it in that it cannot be really successfully imitated.

I come finally to the pearl. This, of course, differs from all other precious stones in being entirely of organic origin. The peculiar luster of the pearl, like the color of the opal, is due rather to its structure than its composition. It is formed in the oyster by the deposition of successive layers of calcium carbonate round some central object, and consists of an innumerable number of thin overlapping laminæ of the crystalline variety of this substance known as aragonite. These layers being semi-transparent, the light falling on the surface is partially reflected from the surface and partially transmitted into the stone, where it suffers reflection from the surface of lower layers.

To produce this complicated structure artificially is practically impossible, unless one can describe as an artificial pearl that formed by the oyster in response to the deliberate introduction of irritant foreign matter by human agency. But in this case, who shall decide where nature ends and human ingenuity begins? Perhaps the well-known Japanese pearl may be correctly described as artificial pearl, although the oyster has a great deal to do with it.

Such pearls are formed by introducing a mother-of-pearl shape between the shell and mantle of the oyster and then leaving the oyster alone for a time to allow it to convert this into a pearl by the deposition of several layers of nacre. The mass is then removed from the shell and converted into the semblance of a true pearl by supplying a back of mother-of-pearl. Such pearls, however, never have the fine orient of those produced under normal conditions, and they can readily be detected by examining the back, when the lustreless mother-of-pearl and the line of junction can be detected.

Of course, wonderful imitations of pearl are made in various ways, which are difficult to distinguish from the natural article by casual examination. One method of preparation is as follows: Small hollow spheres are blown in opalescent glass, coated inside with a preparation of fish scales, and then filled up solid with wax. Such imitations are identified by examination of the hole or by putting a spot of ink on the surface, when the reflection from the inner surface of the glass is seen. These empirical tests are usually sufficient, and it is rarely necessary to resort to testing the specific gravity and hardness, which provide further means of identification. It is worthy of note, however, that such imitation pearls are unique among imitation gems in that, in some respects, they are actually superior to the natural article. They are considerably harder for instance, and their luster is not affected by constant wear.

In conclusion, I would like to refer very briefly to the present position of gems from the economic point of view. It is, perhaps, natural that the considerable influx of artificial gems in recent years, more particularly of the corundum species, has led to a great deal of controversy and difference of opinion as regards their merits. On the one hand the vendors of the artificial stones often publish extravagant statements as to their defying identification, which, as I have shown you, is all nonsense. On the other hand, those interested in maintaining the prestige of the natural article make equally unreasonable statements, to the effect that such artificial productions, to quote a recently published circular, "are as worthless as the jewelry from a Christmas cracker." I have, I hope, clearly shown you the immense difference that exists between the imitation and the artificial ruby, taking an example; the former, it is true, depreciates rapidly in use, and deserves such a description, but the latter has absolutely all the essential qualities of the natural stone, and to place the two on the same plane as worthless trash is unfair to modern science and ingenuity. It must be clearly understood that there is no essential difference discernible between natural and artificial ruby as regards their beauty and their durability, which, as we have seen, are the two great items in the intrinsic value of a stone. But, of course, the price of a stone is chiefly determined by that third factor, which I have not so far taken into account—namely, rarity. Personally, I must confess that I have never been able to see why one should value a thing for no other reason than that it is difficult to get, although I suppose here I am in a hopeless minority, and that it is and always will be human nature to take this view.

It would serve no useful purpose to enter into that fruitful subject of controversy, the price of an article due to extrinsic causes, but I may say this—that while to me personally one is as good as the other, if any man is prepared to pay £100 for a natural stone when he can obtain essentially the same thing, artificially produced, for five, he is absolutely entitled to get it; and I would not wish you to think that I would defend for a moment the man who attempted to supply artificial as natural. But if this is so, it is still more the case that nobody has any right to supply anyone with paste under the name of artificial (or synthetic, or scientific, if these names are preferred) gem. I do think that the distinction between the two should be clearly recognized, and that it should not be permitted to use the term artificial indiscriminately. At present this is being widely practised; every day one sees offered for sale "rubies, emeralds, sapphires, and pearls artificially produced and having all the properties of the natural stone." Now, as I have indicated, such a thing as an artificial emerald answering this description is unknown, and, as a matter of fact, the stones supplied under this title are, as a rule, nothing more nor less than paste imitations, the public being deliberately led to believe otherwise. There is in this case, as I have indicated, a real practical difference between the two articles, not merely a question of opinion.

Again, one must deprecate the custom that has sprung up of arguing that, because "a rose by any other name will smell as sweet," a "scientific" stone will be as good by any other name than its right one. When synthetic yellow sapphire is called "scientific topaz," perhaps no serious fraud is perpetrated, although it is misleading, but when artificial white sapphire is openly and deliberately sold at a fancy price as "synthetic diamond," with the support of the press, I for one consider that matters are going too far, and that this is being done at the present moment anyone can verify for himself. All these misrepresentations may bring wealth to individuals, but they tend to bring into disrepute the artificially-produced gem, and instead of allowing it a place of its own as a distinct achievement, cause it to be looked upon as a spurious make-believe.

Curiosities in Needles.

Needles are articles of such common use and of such small dimensions that one hardly expects to find them present any features of artistic or personal interest. Yet there are one or two instances of this kind on record. Queen Victoria possessed a needle, the stem of which was covered with beautiful designs representing incidents in the life of her late majesty. So small and intricate was the pattern that it could be seen only by the aid of a magnifying glass. Moreover, the needle was hollow and within it was placed another still smaller needle.

The German Emperor, William I., grandfather of the present occupant of the throne, also possessed a very remarkable needle. The story of the circumstances is as follows: In 1883 the Emperor visited a large needle factory in Kreuznach, and one of the workmen, whose task it was to bore the eye of the needles, requested the Emperor to give him one of his white hairs. The Kaiser complied with the request in some astonishment, and was still more surprised when he saw the deft workman bore a hole through the hair, draw a fine thread through the eye, and hand the threaded needle back to the venerable monarch, who kept it as one of the most interesting souvenirs of his long and varied life.

Progress Made by the Metric System.—According to the *Comité International des Poids et Mesures*, the following countries have adopted the metric system: Since January 1st, 1912, it is compulsary in the five Central-American republics and in Greece. In the last named country it was legally introduced since 1836, but its use had been confined to legal commissions. In Bosnia and Herzegovina the metric system will come into general use after September 1st, 1912. In the Anglo-Saxon countries there are still too many opponents against its introduction, although a bill has been introduced in England to adopt the system in the Australian colonies.—*Mechaniker-Zeitung.*

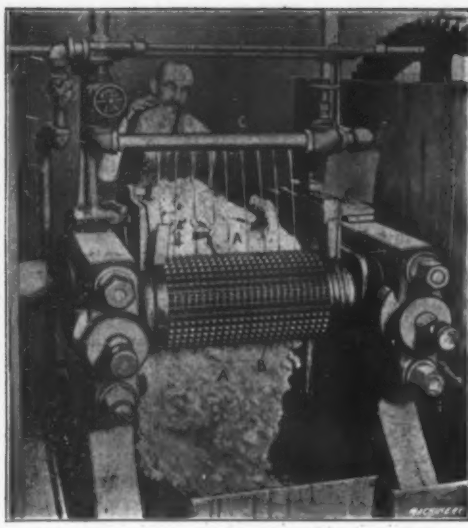


Fig. 1.—Grinding and Washing the Crude Rubber "Biscuits."

Fig. 2.—Covering the Rubber-coated Arbors with Powdered Soapstone Previous to Vulcanizing.

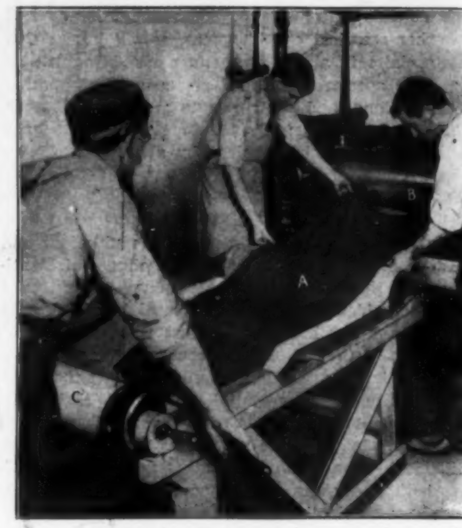


Fig. 3.—Rolling the Rubber Out Into Sheets of the Required Thickness.

Fountain Pen Manufacture*

How One and a Half Million Pens Are Made Annually

By Douglas T. Hamilton

The average user of a fountain pen little realizes the accurate work and care which are necessary to produce it. The turning of the rubber parts presents difficulties which can only be mastered by careful and accurate workmen—specialists in this line. The methods employed in the making of the gold pen point are also unique, and are well worth recording.

The L. E. Waterman Company produces one and one half million fountain pens a year, which requires the combined output of three large factories. The greater number of the rubber pen parts are made at the factory in Seymour, Conn., and the gold pen points in the fully equipped plant in New York city. The factory located at St. Lambert, P. Q., Canada, is required to supply the Canadian field exclusively. There are about 650 men and women employed in all three factories.

OBTAINING THE PURE RUBBER GUM.

The crude "Para Beni-Bolivian" rubber gum, as it is called, is obtained from *Hevea Brasiliensis*, a large tree 60 feet high, which grows on the banks of the Beni River in Bolivia. These trees are tapped by cutting a deep horizontal slit near the base of the tree and a vertical one extending from it up the trunk; from both sides of the vertical incision slits are cut, at short distances apart, in an oblique direction. The tapping is done in the dry season, between August and February, in the evening, and the "milk," as it is called, is collected the following morning, in small shallow clay cups which are fastened below the horizontal incision by a piece of soft clay. When these cups are full, their contents are poured into a larger receptacle. Each tree yields only about two ounces of milk a day, and as the L. E. Waterman Company uses forty tons of rubber per year, this means that upward of 3,000 trees are required to produce sufficient gum—an industry of considerable magnitude in itself.

To produce the rubber, a wooden stick about three feet long, provided with a flattened clay mold at the end, is dipped into the receptacle containing the gum, or milk, the liquid spreading itself evenly on the mold. The milk is then carefully dried by holding the mold over a white vapor produced by heating certain oily palm nuts, the stick being rotated so that the milk is evenly distributed and formed into a sort of gum. Each layer of gum is allowed to become firm before any more milk is added to it. An experienced man can make five or six pounds of gum an hour. The rubber cakes, or "biscuits," thus formed, are slit open in order to remove them from the mold, and are then hung up to dry. The crude rubber is brought down the Beni River, is inspected by a Waterman representative, and is trans-shipped from the seaport Para to the Waterman factory at Seymour, Conn., at which place the crude rubber is manufactured into the rubber pen parts.

WASHING AND GRINDING THE CRUDE RUBBER.

After the gum has soaked in hot water for about two weeks it is taken to the grinding machine shown in Fig. 1, where it is passed through 15-horse-power grinding rolls. These grinding rolls *B*, one of which is shown, chew up the rubber *A*, and cold water, forced out of the pipe *C*, washes the dirt out of it. The rubber is put through these rolls several times until it is cleansed and thoroughly "masticated." After washing, it is placed in a heater, kept at a temperature of about 125 deg. Fahr., where it remains for about two weeks. Then it is put through another pair of rolls where it is again ground and the sulphur is mixed in. One of the rolls travels faster than the other, which tends to strip and separate the rubber sufficiently to allow the sulphur to work in. The correct quantity of sulphur is here mixed in, the operator tearing the rubber off as it comes through, and passing it through again. This operation is repeated until the sulphur and rubber have been thoroughly mixed. The mixing rolls are heated so that the rubber can be properly manipulated.

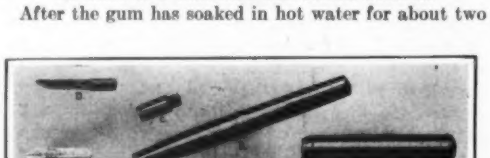


Fig. 4.—Component Parts of Waterman's Ideal Fountain Pen. *A* is the cap; *B*, the barrel; *C*, the Point Section; *D*, the "Spoon" Feed; *E*, the Pen Point; and *F*, a Sectional View of the Assembled Parts.

The rubber is now passed through the sheeting rolls, shown in Fig. 3, where it is rolled out into sheets about 1/32 inch thick. As the rubber sheet *A* passes through the rolls *B*, it is laid on cotton cloth in which it is wound. This cloth prevents it from sticking together and also keeps it clean. It is then wound on a roll *C*, so that it can be easily unrolled when cutting it up into strips for rolling on the arbors. The rolls *B* are heated by means of steam pipes passing through them as is the case in the previous operation. The rubber is kept warm and plastic throughout all these operations.

The sheets are now ready for cutting up and rolling on mandrels, which form the barrel and cap of the fountain pen. This is accomplished by boys who use heated mandrels, cut the rubber into strips sufficient for a pen cap or barrel, and roll it on these arbors to the required diameter, the rolling being done on a heated smooth steel bed. Before starting to roll the rubber on the arbor, a rubber plug of the same diameter as the arbor is stuck on the end of it, which forms the end of the barrel or cap, as the case may be, thus converting it from a tube into a shell form. Foil is then wound over the rubber to prevent the sulphur from "boiling" out, while being vulcanized.

Following this, the arbors *A* with the rubber and foil wound on them are placed in the steel box *B*, as shown in Fig. 2, an even layer of powdered soapstone being first deposited in the box. Then the rubber-coated arbors are placed, as shown in the illustration, far enough apart so that they will not come in contact with one another, after which two wooden strips *C* are laid on top of them. More powdered soapstone is now put in, and the box is filled to the height of the top of these sticks, which act as a gage, so that the soapstone will be of an even depth. The soapstone is then tramped hard to form a mold for the parts during vulcanization. A steel cover is now locked on the box, when it is ready for placing in the vulcanizing oven.

VULCANIZING THE RUBBER PEN PARTS.

Rubber, before vulcanizing, is void of shape and is of little commercial value. Until the advent of this discovery by Charles Goodyear in 1853, rubber was not used to any great extent. Vulcanizing consists essentially of mixing the required amount, about thirty-three per cent by weight, of sulphur with the crude Para rubber, and keeping this in a receptacle, which is heated to about 300 deg. Fahr., for about fourteen hours. Of course the exact time that the rubber should

* Reproduced from an article in *Machinery*, based upon information supplied by Mr. F. P. Seymour of the L. E. Waterman Co., to whom the editors of Scientific American Supplement are also indebted for the plates for the accompanying illustrations.

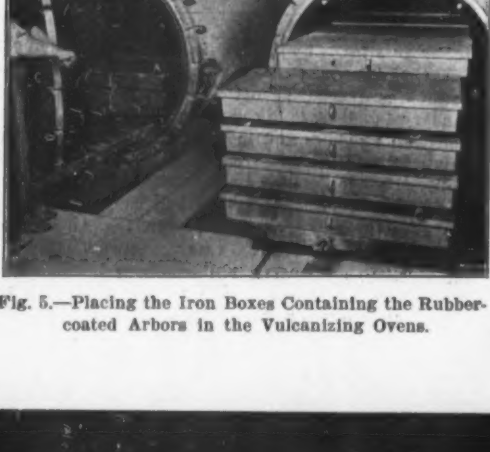


Fig. 5.—Placing the Iron Boxes Containing the Rubber-coated Arbors in the Vulcanizing Ovens.

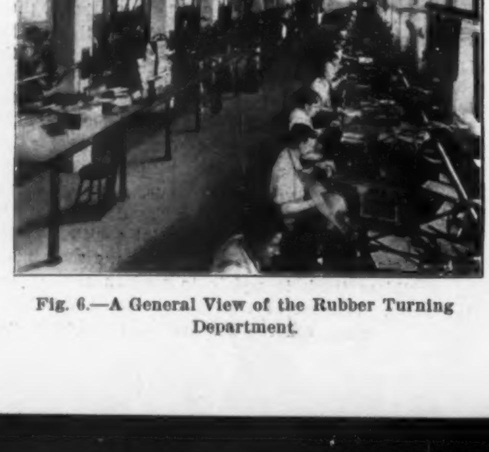


Fig. 6.—A General View of the Rubber Turning Department.

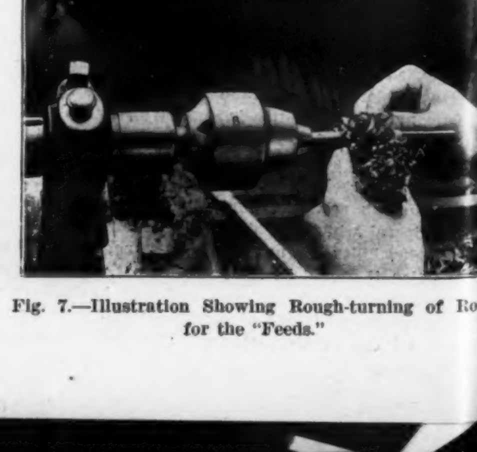


Fig. 7.—Illustration Showing Rough-turning of Rods for the "Feeds."

Fig. 8.—Rough-turning the Rubber Cap.

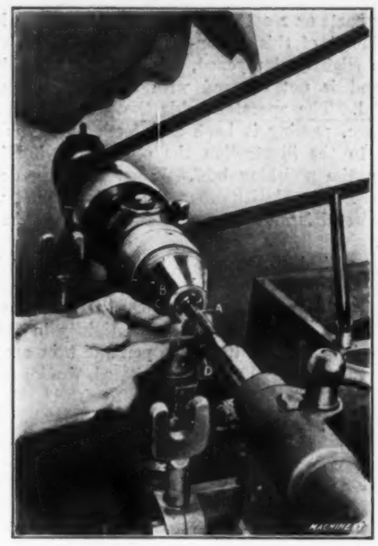


Fig. 9.—Tapering the Ends of the Rubber Barrel.

Fig. 10.—Turning and Threading the Point Section.

be left in, to have the desired resiliency and hardness, depends on the size of the parts being vulcanized. The operator not only has to watch the pressure gage to determine the temperature, but he also has to follow the predetermined lines on a recording thermometer. The smaller the proportion of sulphur in rubber, and the lower the temperature used, the softer and more pliable the vulcanized rubber will be. For fountain pens, the rubber has to be sufficiently hard so that it cannot be easily bent out of shape, and still have sufficient resiliency so that all joints will be ink-tight. It also has to be workable.

After the rubber pen parts have been rolled on the arbors and placed in the steel boxes *A*, the latter are conveyed to the vulcanizing ovens *B* shown in Fig. 5. Here they are placed one upon the other, iron tubes separating them, on a truck which is rolled into the oven. The large iron door *C*, which the operators, at the left of the illustration, are grasping, is then placed on the end and held by swinging bolts. Steam is turned on and escapes into these ovens, and the temperature is gradually brought to about 300 deg. Fahr. After the rubber has been vulcanized, the door is taken off and the car carrying the steel boxes is rolled out, when the rubber is stripped from the mandrel in a special gripper machine. The rubber parts are then ready for turning, after they have been sawed to the desired lengths.

The process of rolling the rubber just described is that generally used for making the cap and barrel, but where long rubber tubes are to be made, they are extruded in a special machine.

TURNING THE RUBBER PEN PARTS.

Vulcanized rubber is not only used for making fountain pens, but it is also employed to a considerable extent for other purposes, especially in the manufacture of electrical apparatus. The rubber used for fountain pens, however, is slightly softer than vulcanite, which is employed in the manufacture of electrical apparatus, but it presents just as difficult a problem in turning. No automatic machines, whatever, are used in the production of the rubber parts (with the exception of chasing), each part having to be made separately by hand, which requires the aid of experienced workmen. A general view of the rubber-turning department in the Seymour shops of the Waterman Fountain Pen Company is shown in Fig. 6, where the turners can be seen at work making the rubber parts of the pen.

MAKING THE RUBBER CAP.

The rubber cap, shown at *A* in Fig. 4, is made from a cup, as has been previously stated, and for the rough-turning operation is placed on an arbor *B* as shown in Fig. 8. The turning is accomplished with a flat hand tool *C*, the operator holding it in one hand, guiding it with the thumb of the other hand, and placing the first finger of the left hand at the back of the work to prevent the cuttings from obscuring his view of

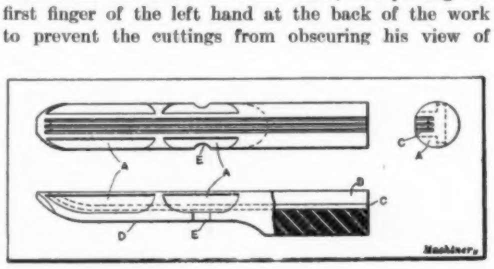


Fig. 11.—The "Spoon Feed" Which Conveys the Ink to the Pen Point.

the point of the turning tool. The free end of the arbor is supported by the tailstock center. The tool *C* is held on a rest *D*, the cutting edge being slightly above the center of the work. In this operation the foil, which was used when vulcanizing to prevent the sulphur from "boiling" out, is also removed. The cap is now finish-turned with hand tools, after which it is reamed taper with a flat reamer made from Crescent tool steel. This is done so that the hole in the cap will fit the tapered ends of the barrel.

MAKING THE RUBBER BARREL.

The rubber barrel shown at *B* in Fig. 4 is rough-turned in a lathe in a similar manner to the cap shown in Fig. 8. The next operation on the barrel is to finish the two tapering ends; one end must fit the taper on the point section, while both ends must fit the tapered hole in the cap. This is accomplished as shown in Fig. 9. The barrel *A* is held in a chuck *B* in a small turning machine, and the operator, by means of a flat hand tool *C*, turns down the tapered ends to the required taper and diameter. The tool *C* is held on a rest *D*, and the taper is governed entirely by presenting the tool at the required angle. The tool is made from 1/8 by 3/4-inch Crescent tool steel hardened "glass-hard." Every time a cut is taken this tool is "touched up" on an Arkansas oilstone, so that the cutting edge is kept as "keen" as possible. If the tool is the least bit dull, it produces a ragged edge and also burns the work, discoloring it somewhat. While tapering the front end, the tailstock center is placed in the hole.

After the front end has been turned, the barrel is reversed and the rear end is turned, tapered and rounded off. The barrel is then ready for reaming and tapping. The reaming is done with an ordinary flat reamer in a speed lathe, while the tapping is accomplished with a tap provided with only two rows of teeth, or, in other words, two cutting edges, the tap being practically flat. This operation is done in a speed lathe which is provided with cross belts, so that the spindle can be reversed for backing out the tap. The operator holds and guides the tap by his right hand, a dog being fastened to the tap so that he can grip it securely.

MAKING THE POINT SECTION.

The point section, shown at *C* in Fig. 4, is that part of the fountain pen which holds the nib and the feed. It is made from tubular rubber, produced by the extrusion process previously mentioned. The first operation is to rough-turn the outside. Then it is placed on an arbor, as shown in Fig. 10, where that part on which the thread is to be cut is rough- and finish-turned. The threading is also done while the point section *A* is located on the arbor *B*, and is accomplished with an ordinary flat chaser similar to that used by brass finishers.

The type of turning rest used for holding turning tools is clearly shown in this illustration. It consists of U-shaped supports *C* in which a round bar *D* rests. The turning tool *E* is fastened to the bar *D* and is supported on the front end by the rest *F*. The bar *D* slides freely in the U-shaped supports *C*, which can be set so that the tool will turn tapering by changing the position of the slide-rest *G*, holding one of the supports. The thread on the point section must be perfect as regards shape, that is to say, it must be

Fig. 12.—Rough-polishing the Rubber Barrels on a Wet Carpet-wheel Buff.

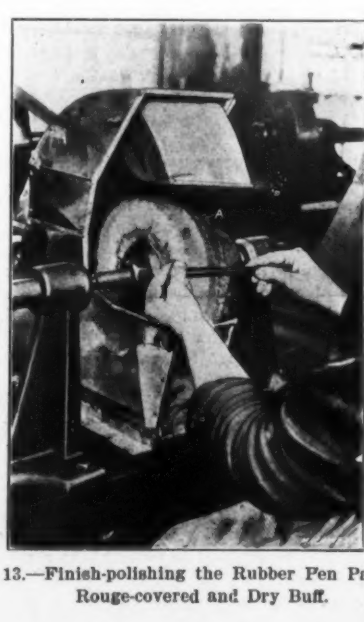


Fig. 13.—Finish-polishing the Rubber Pen Parts, on a Rouge-covered and Dry Buff.

Fig. 14.—The Operation of Riveting the Clip-cap on the Rubber Cap.

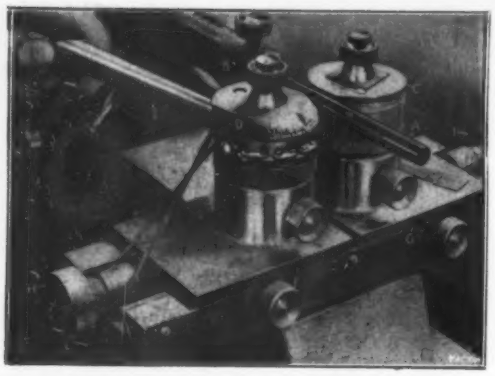


Fig. 15.—Rolling the Name in the Rubber Barrel.

of the same included angle as the thread in the barrel so that the ink cannot leak down past the threads; it is also required to fit tightly in the barrel. After the thread has been cut, the front end is reamed to fit the feed and pen point, after which the external diameter is taper-turned to suit the taper on the barrel, the turning being accomplished in the manner previously described. These rubber turning lathes are rotated at about 2,000 revolutions per minute.

MAKING THE FEEDS.

The "spoon" feed, shown at *D* in Fig. 4, which conveys the ink from the barrel to the pen point, is made from solid rubber, and is cut to the required length from a rubber rod about three feet long. The cut rod is grasped in a chuck *B* as shown in Fig. 7. The turning is accomplished by a small tool made from Crescent steel, held in a holder, which the operator holds in his right hand, guiding it by the left hand as is clearly shown in the illustration. The feed is really the most important part of the fountain pen, with the exception of the pen point, and requires very accurate work. After rod *A* is turned it is again cut into short lengths. Then the pockets *A*, shown in Fig. 11—the peculiar feature of the Waterman fountain pens—are cut. The feed is held in a small fixture, and two cutters, similar in shape to an end-mill, are brought in from each side and fed to the proper depth, and then the table carrying the feed is traversed the required distance. Both pockets on each side are cut in this manner.

Following this operation, the air vent *B* is made with an ordinary slitting saw about 3/64 inch wide, the slit being made about 1/16 inch deep. The next operation is to cut the ink fissure ducts. When writing, the ink passes down these fissures *C*, while the air passes up through the slit *B*, so that every drop of ink in the pen can be used. The feed is now taken to another milling fixture where it is clamped, and the bottom surface *D* is milled to the required shape. This is done in a small miller somewhat similar in action to a profiler, with the exception that the cutter is held in a horizontal plane instead of in a vertical position. The movement of the head holding the milling cutter is controlled by cam-faced guides of the required shape. The small air ducts *E* are produced with a round file. The rubber pen parts are held to a limit of 0.001 inch, being gaged by the operator when turning. They are also again gaged by several of the inspection departments.

POLISHING THE RUBBER PARTS.

All the rubber parts of the pen have now been made, but are in a rough condition—not polished. The first polishing operation consists in holding the rubber pen parts on arbors, and turning them around by hand while they rest on a wet carpet-wheel buff, shown in Fig. 12, on which water is flowing. Ashes and powdered pumice stone are applied to this carpet buff *A*, which removes all tool marks, but does not give a glossy or polished appearance.

The next operation consists in polishing the assembled rubber parts on a cotton-wheel buff as shown in Fig. 13. The side *A* of this cotton-wheel is coated with rouge, and is slightly dampened, while the other side *B* is dry, and is not covered with any sort of polishing material. The operator holds the pen in both hands, as shown, passing it back and forth over this cotton buff. In the illustration the operator is holding the pen on the polishing buff. When roughing down on the buff *A*, coated with rouge, the pen is held in a vertical position and is moved up and down on the face of the wheel.

After polishing, the pen is tested to see that it does not leak. The assembled pen, without the feed or pen point, is located in a tank of water, and a syringe, which has a rubber tube that fits tightly in the point section, is inserted in it. Then pen and tube are placed in the water, and the bulb is pressed, forcing air into the pen. If any bubbles are seen to rise in the water, it is evident that the pen leaks, and it either has to be repaired or discarded. This test is sufficient to expose any imperfections in the fitting of the manufactured rubber parts.

STAMPING THE NAME ON THE BARREL.

As far as the manufacturing operations are concerned, the holder itself is complete, with the exception of having the name stamped on it. This is accomplished in the special device shown in Fig. 15. The barrel is placed on an arbor on which it is clamped, this arbor being connected to a square slide *B* working against the tension of a spiral spring. The barrel rests between two rolls *C* and *D*, the latter roll having the stamp cut in relief, which is to be reproduced on the barrel. The handle *E* for operating the rolls is placed in the roll *D*, the latter being connected to the roll *C* by a block chain. The groove in the roll *C* is tapered slightly to correspond with that on the barrel, and fits it snugly. The illustration shows a barrel just after the stamping operation, the handle *E* being moved to the left when stamping. The rolls are held on sliding bases, *F* and *G*, which can be adjusted back and forth by the thumb-screws *H* and *I*, so that pen barrels of various diameters can have the name rolled on them in this same fixture.

CHASING THE BARREL AND CAP.

The chasing on the Waterman fountain pens is accomplished in special chasing machines, one of which is shown in Fig. 16. The barrel or cap, as the case may be, is placed between centers. In the illustration, six barrels are being chased. The holes in these barrels *A* are placed on close-fitting arbors which have spur gears *B* fastened on the rear end. The other end of the barrel rests in a support *C*, which is counterbored to suit, and in which the barrel rotates. These plungers or supports *C* are provided with springs, so that when the thumb-screws *D* are loosened, the plunger will spring back, allowing the barrel to be removed.

As before mentioned, each arbor that carries a barrel is provided with a spur gear. These spur gears, in turn, are all driven from one central gear, which is located on the arbor *E*, the ratchet plate *F* also being held on this same arbor. A threaded sleeve fitting on the arbor *E* is cut away for part of its circumference. The full part prevents any chasing being done where the name appears on the barrel. When chasing the caps, this sleeve is entirely removed, so that the chasing may be done completely around the cap.

The machine is driven by a belt running on the pulley *G*, which is provided with a tooth clutch. Another tooth clutch on the shaft at the rear meshes with this tooth clutch on the pulley, so that when they are connected the machine will operate. The rear shaft is provided with an eccentric which runs in an elongated slot cut in an arm attached to the moving table of the machine. As the pulley rotates it moves the table back and forth by means of the eccentric, and as the table moves back and forth, a spring-actuated slide *H* comes in contact with a cam block *I*, both of which are beveled as shown. This action forces the spring-actuated slide in, and as it carries a ratchet which meshes with the disk *F*, the latter is rotated. As this

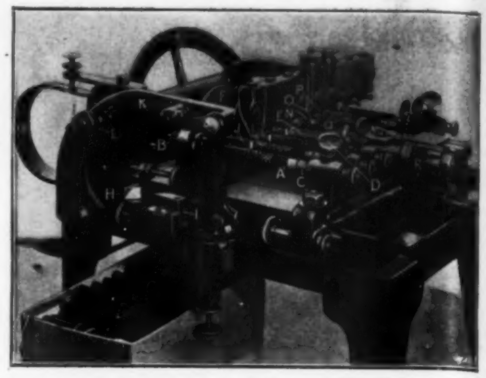


Fig. 16.—Special Automatic Machine for Chasing the Rubber Barrel and Cap.

disk is connected to the central screw *E*, and as the screw is geared up with all of the arbors, it is evident that they all must rotate in unison.

Now, directly over the center of each arbor or pen barrel is a "tool-holder" *J*, in which is held a black diamond, similar to those used in truing emery wheels except that they are finished—having a sharp cutting edge. All sorts of steel cutters have been tried without success. A steel tool will work for a short time, but as soon as it becomes dull, it tears the rubber and makes a very dirty looking job. The head *K* in which these diamonds are held is fulcrumed at *L*, and is compressed by the plate spring *M*. Held in the front end of the head is a stud *N* carrying a roller *O* which works on the sleeve previously mentioned, and also a stud *P* which works on a rack *Q*. This rack lifts the head *K*, so that the spacing between the chased portions is made.

The pattern is controlled by means of a cam *R*, held on the central stud *E*. This cam operates the rack *Q*, changing its position as the rubber barrels are rotated, and by this means the zigzag chasing effect is given to the barrels. It can, therefore, be seen that for each revolution of the driving gear, or, in other words, for each revolution of the pen barrel, six barrels are completed, the time required being six minutes.

The chasing on the barrel, as previously mentioned, does not continue entirely around its circumference. This is accomplished by a sleeve held on the central screw *E*, which lifts up the head *K*, by means of the roller *O*, when it rests on the full portion of the sleeve. Here the machine cuts "air" until the arbor has turned around sufficiently to allow the roller to drop off the sleeve, when the chasing again commences. The machine is stopped automatically by means of a finger attached to the ratchet plate *F*, which comes in contact with a spring-actuated slide, normally kept in contact with an arm, which, in turn, is fastened to the tooth clutch. As soon as this finger touches the slide, it depresses a spring, and at the same time pulls the former from the cam on the lever, thus allowing the latter to be acted upon by another spring, which disconnects the clutch, thus stopping the machine.

PUTTING ON THE CLIP-CAP.

The clip-cap, which is used for holding the pen in the pocket, is held to the cap by means of a twin rivet. The holes for the twin rivet are drilled in an ordinary drill press, after which the rivet is placed in a slotted arbor, the latter being inserted in the cap, then pushed up forcing the two prongs of the rivet through the holes. The cap is then taken to the foot-press shown in Fig. 14, where the operator places it on an arbor. Here the cap *A* with the arbor in it is laid in a groove cut in a lead block *B*, the latter being held in a cast-iron shoe *C*. The riveting is done with a small punch *D*, provided with a circular depression in its lower end, the operator simply pressing the foot-treadle, bringing the punch down on the top of the twin riveting prongs, and thus setting them.

Drawbridge in Constant Equilibrium Without Counterweight

By A. RAMNEKERS and M. E. J. GHEURY.

IN ordinary bridges, the weight of the moving parts is invariably balanced by a counter weight, the mass of which is equal to that of the bridge itself, so that the latter is in equilibrium. This has for immediate result to double the mass to set in motion, so that the mass of the combined system of bridge and counter-weight is considerable. Frictional resistances are therefore considerably increased by the addition of the counter-weight, and, unless the pivots are kept very clean, the operation of the bridge is rendered slow and weary, yet, a military draw-bridge may be required to remain down till the the last moment, in order to allow a retreating defensive force to enter. It must be such as to be drawn without exposing many men to the fire of the attacking party, possibly with a very small margin of time allowed for its operation.

The draw-bridge described hereafter is not open to the objection noted above; it has no counter-weight and it is in perfect static equilibrium in all positions, the principle upon which it is constructed being such, if the center of gravity of a bridge be displaced so as to remain in the same horizontal plane, the equilibrium of the body being indifferent, no work is done in moving the body in the manner stated, except the work unavoidably wasted in overcoming the friction at the pivots and at the guiding rails. In this case, the absence of a counter-weight reduces to a great extent the amount of frictional resistances opposing the operations of the bridge.

In figure 1, *A B* is the longitudinal axis of the bridge through its center of gravity in the lowered position, the length of span being *l*. *A' B'* is the drawn position. The nose *B* is constrained to move about a point *O* as center, and describes a circumference of radius *r*. The height *h* of the pivot *o* above the line *A B* must be determined so as to satisfy the condition that the center of gravity *G* of the bridge, situated at the middle of the span, is constrained to move exactly along the horizontal line *A B*. In order to do this, the tail *A* of the bridge must be constrained to move along a certain definite path by guiding rails of a suitable shape and design. The position of the pivot *o* determines the length *r* of the tie rods supporting the nose of the bridge.

Now, $r = OB = OB' = h + \frac{l}{2}$.

also $r^2 = l^2 + h^2$.

These two equations give $h = \frac{3}{4}l$ and $r = \frac{5}{4}l$.

The guiding rails of the tail *A* must be of such shape as to constrain it to move along the locus determined by the conditions of the motion, we have therefore to ascertain the exact nature of this locus.

Selecting *A X*, *A Y* as axes of coordinates and cen-

structing an intermediate position $A'' B''$ of the bridge, we have

$$y = \frac{l}{2} \sin \theta \quad \ldots\ldots (1)$$

Now $$B''D^2 + DO^2 = r^2$$

or, since $A''F = FE$

$$B''D^2 + (h+y)^2 = r^2$$

so that $x = EB'' - B''D = l \cos \theta - \sqrt{r^2 - (h+y)^2}$

and $$x = l \cos \theta - \sqrt{r^2 - (h + \frac{l}{2} \sin \theta)^2} \quad \ldots\ldots (2)$$

In order to eliminate θ between (1) and (2) we may write, since $h = \frac{3}{4} l$ and $r = \frac{5}{4} l$,

$$(x - l \cos \theta)^2 = r^2 - \left(h + \frac{l}{2} \sin \theta\right)^2 = \frac{25}{16} l^2 - \left(\frac{3}{4} l + \frac{l}{2} \sin \theta\right)^2$$

that is

$$x^2 - 2lx \cos \theta + l^2 \cos^2 \theta = \frac{25}{16} l^2 - \frac{9}{16} l^2 - \frac{l^2}{4} \sin^2 \theta - \frac{3}{4} l^2 \sin \theta$$

and, as $\sin \theta = \frac{2y}{l}$ and $\cos \theta = \sqrt{1 - \sin^2 \theta} = \sqrt{1 - \frac{4y^2}{l^2}}$,

we get

$$x^2 - 2lx \sqrt{1 - \frac{4y^2}{l^2}} + l^2 \left(1 - \frac{4y^2}{l^2}\right) = l^2 - \frac{l^2}{4} \times \frac{4y^2}{l^2} - \frac{3}{4} l^2 \times \frac{2y}{l}$$

which gives after reduction

$$9y^4 + 10x^2y^2 + x^4 - 9ly^3 + 3lx^2y + \frac{9}{4} l^2y^2 - 4l^2x^2 = 0,$$

the equation of the locus of the tail of the bridge.

This expression could be written

$$x^4 + x^2(10y^2 + 3ly - 4l^2) + \left(9y^4 - 9ly^3 + \frac{9}{4} l^2y^2\right) = 0.$$

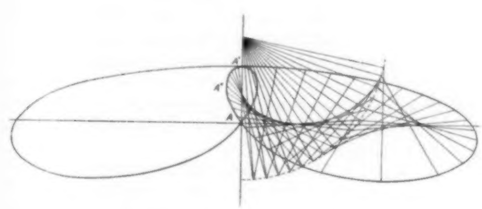


Fig. 2. Locus of the Tail of the Bridge.

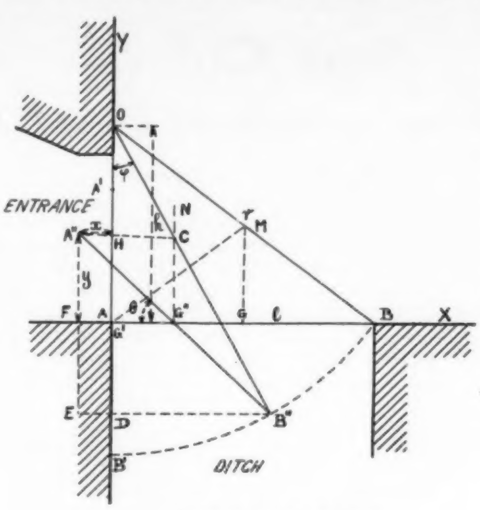


Fig. 1. Diagram of Drawbridge.

It is of the form $x^4 + Ax^2 + B = 0$, an equation whose roots are given by

$$x = \pm \sqrt{-\frac{A}{2} \pm \sqrt{\frac{A^2}{4} - B}}.$$

For every positive value of x, there will be also an equal negative value of x, hence the locus will be symmetrical with regard to the axis of y.

For $x = 0$ we get

$$9y^4 - 9ly^3 + \frac{9}{4} l^2y^2 = 0$$

$$\text{or} \quad 9y^2\left(y^2 - ly + \frac{1}{4} l^2\right) = 0$$

$$\text{or} \quad 9y^2\left(y - \frac{l}{2}\right)^2 = 0$$

that is, either $9y^2 = 0$, giving two roots equal to zero or $\left(y - \frac{l}{2}\right)^2 = 0$, giving two roots equal to $+\frac{l}{2}$.

The curve passes therefore twice through the point whose coordinates are $x = 0$, $y = \frac{l}{2}$, that is, the point A', and crosses itself at the origin.

For $y = 0$, $x^4 - 4l^2x^2 = 0$

or $x^2(x^2 - 4l^2) = 0$,

hence $x^2 = 0$, giving two roots equal to zero and $x^2 = 4l^2$, giving two real roots $+2l$ and $-2l$.

The locus is the figure shown, figure 2.

In practice, only the portion $AA''A'$ of this curve is made use of. It is formed by two curved rails, one on each side, upon which the tail of the bridge fitted with suitable wheels, is rolling.

The normal to the path of B is the radius OB''; (Fig. 1) the normal to the path of G is the perpendicular $G''N$ to AB through G''. These meet at C which is therefore the instantaneous center of rotation of the bridge. Hence, if we join CA'', this line is normal to the path of A. If we assume little friction, and there should be little with well designed rollers, the reaction of the guiding rail is approximately normal to it, that is, along CA''. The weight W of the bridge, the tension T in the tie rod and the thrust P on the guiding rail, being along the lines CG'', CB'', CA'', respectively, the triangle COH is the triangle of force corresponding to the position $A''B''$ of the bridge. From the triangles of forces corresponding to the various positions of the bridge, a study of the variations of T and P can be readily made. The following table give the ratios $\frac{T}{W}$ and $\frac{P}{W}$ for various positions, and these results are embodied in the graphs of Fig. 3. It is seen that the maximum value of the tension in the tie bars is 1.35 times the weight of the bridge. At rest, in the lowered position, this tension is equal to the thrust on the guiding rails, as one can verify at a glance on Fig. 1, since BM and AM are equally inclined to the horizontal:

	$\frac{T}{W}$	$\frac{P}{W}$	ϑ	$\frac{T}{W}$	$\frac{P}{W}$
53°	0.835	0.835	20°	1.285	0.500
50°	0.885	0.808	15°	1.323	0.441
45°	0.972	0.758	10°	1.340	0.390
40°	1.052	0.702	5°	1.335	0.358
35°	1.124	0.646	2.5°	1.244	0.242
30°	1.183	0.588	0°	1.000	0.
25°	1.240	0.532			

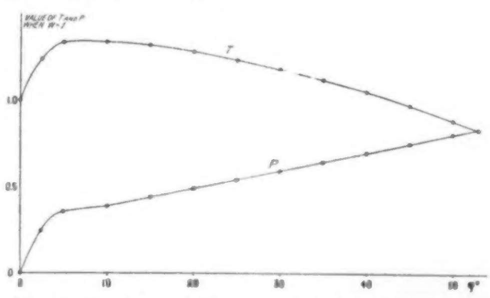


Fig. 3. Tension and Thrust at Different Inclinations.

The Archæology of Copper and Its Alloys*

Notes on the Early History of Metallurgy

In the opening paragraphs of his address Prof. Gowland pointed out that in the discovery of metals and their alloys we had one of the great turning points in the history of human development, since this discovery constituted the germ of to-day's culture and civilization. The order in which the metals were discovered was not the same in every part of the world, and in all probability native metals were those the utility of which first became known. These were copper and gold. But the latter, though more widely distributed than copper, was almost worthless for industrial purposes. Copper itself was, moreover, only used to a limited extent, not being well suited to the construction of weapons and the like; but its fusion with tin yielded an alloy of which the physical properties were only surpassed by iron. Ancient writers had, Prof. Gowland stated, concluded that the discovery of metal-smelting was due to the burning of a forest covering an outcrop of ore, but it actually arose in a more commonplace fashion. Elaborate furnaces were, in fact, not necessary for the reduction of many ores, and the discovery of the process arose from the accidental use of lumps of ore to form the ring of stones inclosing a domestic hearth, so that the camp fire was the first metallurgical furnace. The next step in the evolution of the latter lay in the formation of a shallow cavity in the hearth for the reception of the molten metal, which was deepened as time went on. Furnaces of this primitive form survived in Derbyshire up to the seventeenth century, and in Japan were in universal use up till 1858 for the smelting of copper, tin, and lead; and though as simple and crude as those of the bronze age, were still extensively employed in that country. The alloying of tin with copper was effected originally by melting together copper ores with tin-stone. Continental archæologists had, Prof. Gowland stated, asserted that bronze could not be produced in this way; but he himself had conclusively proved the contrary by actual trial in a furnace of the primitive type.

The lumps of ore found in such "founders' hoards," as had been discovered, were disks of copper, 8 inches to 10 inches in diameter by 1½ inches thick, and were produced in a small shallow hole in the ground, 10 inches or 12 inches in diameter, charcoal being used as the fuel. The slag was raked off, and the metal was not ladled out, but allowed first to solidify, and then immediately raked out and broken up on a large stone, as was still the practice in Korea in 1884.

Copper from the bronze age contained often only traces of sulphur, and ranged in purity from 97 to 99 per cent Cu; hence it must have been originally produced from a very pure ore, or have been subsequently refined. Analyses of the primitive bronze alloys showed, he continued, variations in the content of tin, which ranged from 3 per cent up to as much as 18 per cent. The higher percentages were used for swords and the like, and the low for axe heads. All the copper celts were cast in open molds, the metal from the smelting operation being remelted in crucibles and poured into molds of clay or stone. The crucibles used were of an unrefractory clay, and had to be buried in the ashes of the hearth to protect them from the extreme heat of the fire. They were removed from the furnace by placing a stick in a socket, formed for the purpose. Bronze implements on the other hand were cast in closed molds either of clay or of bronze. One of the latter had been found containing a core, and it differed but little from present forms. In casting thin articles, such as swords and daggers, the mold was of clay and made red hot before the metal was poured in, a method which Prof. Gowland stated was still practised in Japan. The hardness required at the edge was given by hammering. On this point Prof. Gowland stated much misconception prevailed, statements being prevalent that the men of the bronze age had methods of tempering which made bronze harder than could be done to-day. As a matter of fact modern bronze could by hammering be made as hard as any prehistoric samples, and much harder than most.

Bronze from Nineveh, dated 1000 B. C., contained from 10 to 18 per cent of tin. In some cases it was cast over iron rods, the latter being relied on to give strength, while the bronze was used for decorative reasons. Bells found had 14 per cent of tin, showing that the Assyrians knew well the effect of changing the proportion of the metals. The statements of Pliny as to bronze in Roman times were, Prof. Gowland continued, for the most part useless and misleading.

Brass was the discovery of the Romans, being obtained by melting ground calamine with copper granules. At the outset the temperature was kept low, so that the zinc was reduced and distilled, combining with the still solid copper, converting it into brass. On then raising the temperature the latter was melted and could be poured into molds. This method of preparing brass was still used at one works in Birmingham as late as 1861. The present method of forming the alloy from metallic zinc originated with Emerson in 1781. Roman brass, Prof. Gowland stated, was of excellent quality, being one of the most ductile of the whole series of brasses. With the disappearance of calamine brass one of the last links connecting modern metallurgy with that of antiquity was broken, but, on the other hand, the *cire perdue* process of casting bronze still remained substantially the same as employed by Greek founders some centuries before our era, and the art of copper refining was in principle the same as at the time of Pliny.

*Presidential address read before the Institute of Metals, and reported in *Engineering*.

Star Colors*

A Method of Verifying Accurately the Crude Judgment of the Eye

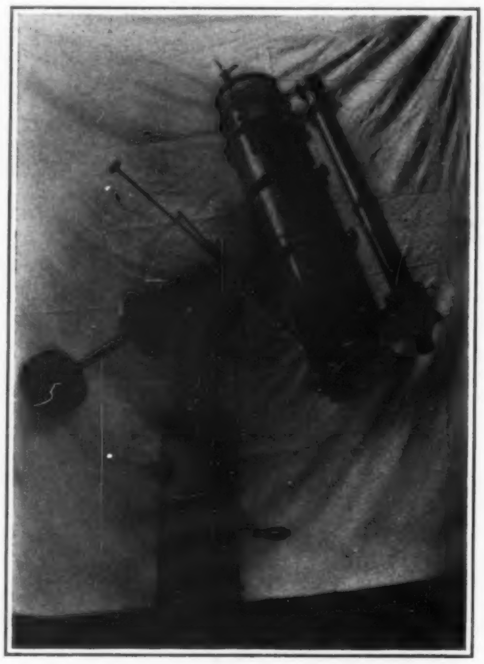
By C. H. Gingrich

In the thoughts of those who have not given especial attention to astronomy, the sun and the stars belong to two classes which are very different in many respects. The sun quite obviously is constantly changing its position of rising and setting, being much farther north in summer than in winter, while the stars seem to be stationary. The sun gives warmth and light, without which the earth would be barren and desolate, while the stars are entirely negligible in regard to the heat they send us and almost so in regard to the light. The sun presents to our view a large disk, but the stars show only a faint flickering light coming apparently from a point or at most from a very small area. It is, therefore, with astonishment that we learn that the sun is nothing more than one of the great host of stars that adorn the vast expanse of the cloudless, moonless sky, and that it is much smaller and much less bright intrinsically than many of the class to which it belongs. It seems so much larger and so much brighter than the other stars because of its proximity to us, and not because it is the most magnificent body in the universe.

Again, most people would doubtless say that the sun is different from the stars in the character of the light it sends. The sun shines with a decidedly yellow light while the stars shine so faintly that, if they do not all send us the same kind of light, they do not attract our attention by the preponderance of their color as the sun does with the pale gold of its rays. While, from a superficial consideration of the sky, one might assent to the above, he could not long do so after his attention had been directed to a few of the bright stars. To the naked eye there are stars which present the various colors of the spectrum from the blue to the red. The brightest star in the sky, Sirius, may be taken as representative of the class of stars which give white light. Although Ptolemy speaks of this star as "fiery red," it is certainly very far removed now from the red. Stars of this kind are often spoken of as white stars. Sirius, indeed, sometimes seems to go beyond the ordinary white star and to show scintillations of blue. Vega, the brightest star in Lyra, Castor one of the twins, both very bright stars, and the well known variable, Algol, are other examples of pure white stars. Mirfack, α Persei, the brightest star in Perseus, Procyon, the brightest star in Canis Minor, and Polaris, the Pole star, are examples of stars which are not pure white stars and which, on the other hand, do not exhibit any great degree of color. Proceeding in the series we find Capella, the brightest star in Auriga, showing considerable color, very similar to the pale yellow of the planet Saturn. At this stage we have stars of the same kind of light as the sun. But we have not yet come to the end of the series. Even among the bright stars there are some which shine with a decidedly red light. The most notable of this class among the bright stars are Arcturus, the brightest star in Bootes; Aldebaran, the brightest star in Taurus; Betelgeuse, the bright star in the well known constellation Orion north of the three belt stars; and Antares, the brightest star in Scorpio.

Although these different shades of color are apparent to the naked eye of any one trained even only to a slight degree in distinguishing colors, a telescope does much in the way of emphasizing the effect. It may be well, however, to caution those who are not familiar with telescopic views, that there is usually very much more color in the telescopic view of a bright star than really belongs to the star itself. It is very difficult to correct the objective lens entirely for what is called chromatic aberration. Hence, there is usually seen a fringe of color, about the image of the bright stars, which has its origin in the lenses of the telescope. Some color also is due to the atmosphere of the earth.

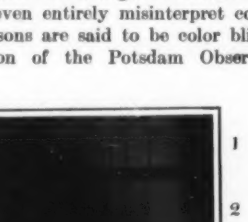
This variety of color is characteristic not only of the naked eye stars but of the fainter stars also. Indeed, some of the faint stars show much greater depths of color than the bright stars already mentioned. Hind, who first noticed the variable star, R Leporis, in 1845, said that it appeared to him like "a drop of blood on a black field." The deep red of this star changes to a fainter red, almost copper, color as the star becomes brighter. Sir John Herschel describes a star of about the eighth magnitude near the Southern Cross as of "the fullest and deepest maroon-red, the most intense blood-red of any star I have seen. It is like a drop of blood when contrasted with the whiteness of β Crucis." These are a few of the many stars that might be mentioned as having very striking intensities of color. Many of the variable stars vary in color during their period, being more highly colored when near the minimum. The reason for this may be that the red rays are in excess and when the light of the star is diminished the rays other than the red are all absorbed in the atmosphere of the stars, the red rays only being able to escape the absorption. Temporary stars, the Novae, also manifest different colors in their development. They, as a rule, lose color as they become fainter,



The Zeiss Ultra-Violet Camera of the Yerkes Observatory.

which is the reverse of the order in the case of variable stars.

We should be inclined to speak much less confidently of the different colors in the stars if we were dependent upon the eye alone for the estimates of color. Some persons have very delicate color perception while others are entirely unable to distinguish between the finer shades or may even entirely misinterpret color sensations. Such persons are said to be color blind. In a recent publication of the Potsdam Observatory in



The Spectra of (1) Algol, β Persei; (2) Mirfack, α Persei; (3) Capella, α Aurigæ; (4) Saturn; (5) Aldebaran, α Tauri.

Photographed Oct. 12, 1911, by C. H. Gingrich with the Zeiss Camera and the Objective Prism, Yerkes Observatory

which the visual magnitudes of all the stars in the Argelander catalogues of magnitude 7.5 or brighter, 14,199 in number, are given, the observers have assigned fourteen different shades of color, ranging from white to red, to the various stars in their list. Their color perception is very keen, since they are able to distinguish fourteen shades where the ordinary person could see possibly only four or five at the most. These fine distinctions might be thought to be merely imaginary if it were not possible to verify them by some means. Fortunately the color of a star is only an indication of the actual condition of the star and its atmosphere, and if two stars can be shown to differ in the character of their component materials there is then a basis for a difference of color, which difference may be apparent to the well trained eye only.

The composition of the distant stars can, indeed, be known. The breaking up, or technically the dispersion, of composite light into the various colors of the rainbow in passing through a glass prism is a well known phenomenon. The prismatic effect is different for different sources of light, and it is also modified by interposing different kinds of gases between the source of light and the prism. These varied results are well known facts in physics, and the particular result in any case points directly to definite conditions which cause it. The light from the stars, if allowed to pass through a prism, coming, as it does from the sun, from a luminous body through the various gases in their atmosphere is obviously subjected to the same conditions as are formed in the laboratory by interposing a particular gas between the source of light and the prisms. The distance is not of any consequence since the essential elements are the light waves, which require more time to arrive from the stars than from some terrestrial point but which are not changed in character.

It remains then to collect a sufficient quantity of light from the star, let it pass through a prism and fall upon a sensitive plate and the star itself tells the story of its composition. In order to get a sufficient amount of light from the star it is necessary to gather it and to bring it to a focus by means of a telescopic lens. The light may be allowed to pass through a prism before or after it has passed through the lens and the desired dispersion will be secured in either case. In the latter case the spectrum is secured by the use of a spectroscope. The second accompanying illustration shows the result of the light passing through the prism and then through the lens. The arrangement of the instrument for producing the results shown will now be described.

The prism called the "Objective Prism" is set in a cell which is of such a size as to fit exactly over the cell that contains the six-inch ultra-violet objective lens of the Zeiss camera of the Yerkes Observatory. The objective prism cell is held in place by screws and the balance of the instrument is re-established by sliding the entire tube a short distance in its cradle and by adding a counterweight to the declination axis. It can be put in place or removed in a very short time. The prism has an angle of 15 degrees and consequently does not give so much dispersion as a prism of greater angle would give. What is lost in dispersion, however, is gained in intensity of light and the spectra of fainter stars can be secured than would be possible with greater dispersion, other things remaining the same. The prism is so placed that the spectrum of the star, which is a narrow band of colors, extends in a direction at right angles to the diurnal motion. If then the telescope is not moved while the star drifts because of the diurnal motion, the narrow spectrum can be widened to any desired extent on the photographic plate and thus be made a better image for study. If the star is faint it must be made to drift repeatedly over the same part of the plate in order to make an image.

The stars that are shown in the illustration are not found in the sky in the position that the plate would indicate. They were brought into these positions for the purpose of comparison by exposing on one of the stars and then making an entirely different setting of the telescope and exposing on another. Stars 1 and 2 should be shifted slightly to the left to bring them into perfect alignment with the other three. The illustration shows the positive of the spectra and consequently the dark lines are absorption lines.

A mere glance will suffice to show marked differences in the spectra of the stars used. Algol, on this scale, shows a series of lines which are known as the hydrogen series. These are absorption lines and indicate the presence of hydrogen in the atmosphere of the star. There are numerous other lines in the spectrum which are too fine to appear on the scale of these spectra. The hydrogen lines are designated, beginning at the right which corresponds to the red end of the spectrum, as Hα, Hβ, Hγ, etc. Hα is too far in the red to appear. There is just a suggestion of Hβ, but after that the series is quite prominent until it again fades out at the blue end of the spectrum. Stars of this class are called stars of the first type. The next star, α Persei, shows the hydrogen lines very much fainter than Algol shows them and also shows some new lines.

One of these is seen just to the left of Hγ and is known as the solar G group. Another and even more prominent line appears in this star between Hε and Hζ. This is known as the K line and indicates calcium. This star is of the class F, and is intermediate between the first and second types. The next two spectra, those of Capella and of Saturn, show a marked similarity. The hydrogen series has disappeared, on the small scale of the illustration, and the solar G group and

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* Reproduced from *Popular Astronomy*. The illustrations are prepared from lantern slides kindly supplied by the Yerkes Observatory.

the K line have become much stronger. Also the H line, another calcium line to the right of the K line, is very prominent. These spectra are of class G, or of the second type. Stars having this spectrum are also frequently spoken of as solar type stars, because their spectra resemble closely the spectrum of the sun. It is quite natural that this should be the case because the light from Saturn, one of our examples, is reflected from the sun. The last star, Aldebaran, shows a still different spectrum. There are numerous fine lines but those that were prominent in the other stars are here very weak or entirely lacking. There is also a decided falling off in the intensity of the spectrum toward the left or violet end, showing that the great preponderance of light is in the red region. This star belongs to class K, intermediate between the second and third types.

Beyond these there are stars of still different types. They are for the most part, however, among the fainter stars. Between the examples here shown there are stars which form a continuous gradation from one type to the next. This continuity suggests very strongly progressive development, processes of evolution among the stars. The direction in which this development is moving is still subject to question. It is supposed that the white stars, those in which the hydrogen lines are prominent, are comparatively young, and that those of the later types, such as Aldebaran, have advanced much farther in their development. It may be, however, that the tendency is in exactly the opposite direction, since the changes are so slow, according to our idea of time, that no progress has been noted in any particular star since this method of study has been employed.

Whatever direction the process is leading, since the sun does not form either extreme in the series, but occupies an intermediate stage, it is quite probable that the sun still has a long life to live, and that many, perhaps we may say countless, generations of men will pass before the sun will show signs of decline, and before it will no longer serve the earth in the same capacity as we know it now.

Can the Lower Animals Renew Their Youth?

Remarkable Regenerative Powers of Primitive Types

By S. J. Holmes

We commonly regard life as proceeding inevitably from youth to old age. Typically an organism begins its existence as a single cell which after passing through a more or less complex development arrives at the mature or adult state. After a time the process of senescence steps in and the organism is sooner or later overtaken by the unavoidable nemesis of natural death. During development the cells of the body pass from a condition in which they are immature, plastic and unspecialized to one in which they are differentiated into many specialized varieties, each performing some particular function. Development does not stop with the completely formed embryo, but continues through

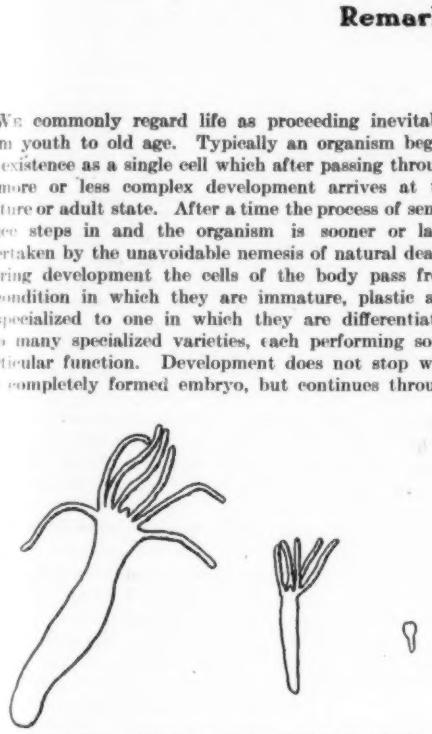

Fig. 1. Hydra, Showing Three Successive Stages of Reductions Through Hunger. (After Schultz.)

life; and the period of tottering age when the subject becomes "sans teeth, sans eyes, sans taste, sans everything," is as truly a part of its normal life history as the gastrula stage or the period of birth.

What brings about natural death is an unsolved biological problem, although there has been no dearth of theories offered as a solution. In recent years we have heard much, especially through Metschnikoff and his followers, of attempts to stave off the process of growing old, and certain theorists have held out hopes that by the employment of the proper methods we might be able to attain an almost indefinite prolongation of life. No one has yet discovered, nor perhaps is likely to discover any catholicon which achieves this result, although it is quite possible that life may come to be greatly prolonged beyond its present average expectation. Preventing the onset of old age is like stopping development at any particular period, and with the higher organisms science knows no method, save that of killing them and keeping them in preserving fluid, of accomplishing this end.

A few years ago Dr. Loeb made the suggestion that the vital processes may be reversible and that, under certain conditions, the organism may go back to a more embryonic stage. He based his suggestion on certain phenomena observed in a species of hydroid, Campanularia, parts of which were found to undergo a regressive metamorphosis under certain conditions, resorbing the tentacles and losing other specialized structures. Driesch, a short time later, in experimenting on the regeneration of a tunicate, Clavellina, found that in many cases the complex structure of the branchial basket underwent a process of degeneration into a comparatively undifferentiated mass which subsequently developed into a new individual. Before going forward to form new organs the tissues were apparently compelled to go backward to a more primitive stage, a process which Driesch in common with Loeb designated as a reversal of development.

The most extensive contributions to this subject have been made by Dr. Eugene Schultz, who has written a very suggestive essay, "On reversible processes of development," in which most of his own researches and those of others are summed up. Schultz found that many of the lower invertebrates when kept without food gradually diminish in size until at last they are but a minute fraction of their original dimensions. The common fresh water Hydra was kept in pure water without food for several months during which time it underwent a diminution to less than 1/100 of its former size. Toward the latter part of its period of diminution it began to undergo also a simplification of structure. The tentacles grew relatively shorter and decreased in number. Finally they all disappeared. The body became more rounded and at last the mouth opening closed, the animal becoming converted into an almost spherical mass of living cells, resembling the blastula stage of its early embryonic history.

Similar experiments were undertaken with a small flat worm, Planaria. This species is one of remarkably tough constitution and endures a period of several months' starvation. During this time the organism, as it were, lives on itself, and as there is nothing from the outside to supply the waste, it gradually grows smaller and smaller. Berninger, who repeated Schultz's experiment, succeeded in reducing planarians in this way to only 1/500 of their original bulk. Both Schultz and Berninger studied the cells of these minute individuals and found them to be of the same size as in full grown planarians. The small size of the worms, therefore, is brought about, not by a diminution of the size of the cells, but by a reduction of their number. And perhaps this fact has some relation to our inability to carry the reduction in size beyond a certain point. If the planarian is to continue a planarian and keep its digestive, muscular, nervous and other organ systems in any degree of functional efficiency it must have cells enough to go around and give each system a certain minimal number. While the starved planarians continue to be fairly active and efficient organisms, they showed, however, a considerable simplification of structure. The organ systems suffered unequally. The yolk glands disappeared comparatively early; then followed the ducts and various accessory apparatus of the organs of reproduction, but the germ cells themselves held out to near the period of death by starvation. The other organ systems continued to bear much the same relation to one another as in the normal animal.

Throughout this remarkable reduction in which various cells succumb one after the other and become resorbed by their fellows, we nevertheless find the preservation of a certain balance of function or organic equilibrium, even when the cells had been thinned out to 1/500 of their original number. The organism is like a factory which is compelled to run with a small fraction of its force of employees. There may be a few classes of its employees such as its advertisers, which may be dispensed with in periods of greatly diminished output, but if the factory keeps going it must have a certain number at least of various kinds of workers.

Another method of bringing about reduction of size and simplification of structure is by causing the organism to undergo a large amount of regeneration. For this purpose the fresh water planarians afford again most favorable subjects for experiment. These animals may be cut into small pieces less than one-twentieth of their original size, each of which will transform itself into a miniature planarian. By subjecting these forms to successive regenerations they may be kept retransforming themselves for a long time. The present writer has carried on a series of experiments on reduction in planarians by first cutting an individual into about twenty pieces. After these had regenerated, each was cut into several smaller pieces. When these had regenerated into still smaller worms they were again cut into several pieces, and the cutting was continued until the pieces would no longer regenerate. I succeeded in this way in obtaining individuals which were less than 1/1,500 of the bulk of the specimen with which I started.

These minute forms would move about and react to stimuli in almost exactly the same way as normal planarians. Sections showed that the cells of the body were not at all reduced in size, and that the brain, nerves, muscles, and sense organs stood in much the same relation as they do in individuals of the usual size, except that in the cases of the most extreme reduction the eyes were imperfect or entirely absent. No trace of yolk cells or reproductive organs could be

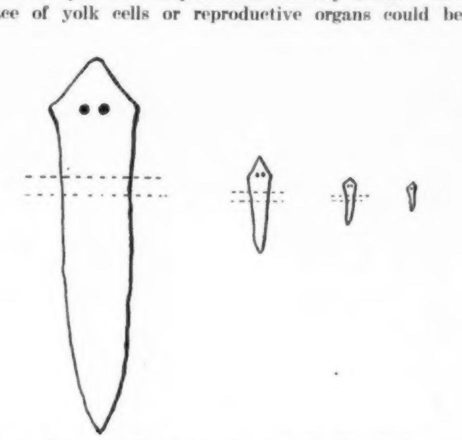

Fig. 2. Planaria Maculata, Showing the Diminution in Size From Successive Regenerations. The Parts Between the Dotted Lines Regenerate into the Smaller Individual Shown at the Right.

found, as might be expected from the fact that these parts appear comparatively late in the development of the individual.

In the regeneration of these forms there is not merely the production of new tissues which develop into the missing parts. The process consists mainly in working over the old tissue into new organs until the whole animal is transformed into what has all the appearance of being a much younger individual. What a wonderful process of undoing and rebuilding during these successive regenerations!

How long such plastic creatures as Hydra or a planarian may be kept going back and forth between the embryonic and the differentiated state is not known. It is not improbable that senescence may be checked in this way for a long time. The power of reversing the processes of development is most conspicuous in those forms in which the ability to regenerate is unusually great. With the loss of regenerative capacity organisms lose the power of renewing their youth and their term of life becomes less subject to wide fluctuations. Some of the lower organisms may be able to evade natural death for perhaps an indefinite period, but all of the higher animals and plants seem hopelessly committed to the habit of dying after a certain fairly constant interval of time.

The Length of Life of Organisms.—Interesting figures regarding the normal length of life of a number of organisms is given by a naturalist in *Süddeutsche Apotheker Zeitung*. The day fly lives 24 hours; the May bug 6 weeks; the butterfly 2 months, as alas, also does the flea; the fly 3 to 4 months; the ant, the cricket and the bee one year each; the hare sheep 6 to 10 years each; the nightingale 12 years; the wolf 12 to 15 years; the canary bird 15 to 20 years; the dog 15 to 25 years; cattle 25 years; the horse 25 to 30 years; the eagle 30 years; the stag 35 to 40 years; heron, lion, and bear 50 years each; the raven 80 years; elephant, turtle, parrot, pike and carp 100 years each. The ivy outlives 200 years, the elm 300 to 350 years, the linden 500 to 1,000 years; the locust tree and the oak 400 years; the fir 700 to 1,200 years, and palm trees 3,000 to 5,000 years.

The Cause of High Prices*

A Suggested Remedy: Bring the Consumer Nearer to the Producer

By U. S. Senator T. E. Burton

If the student of present day affairs should classify the reasons for existing discontent, he would certainly give to the high cost of living a position in the front rank. Dominant political parties, ruling ministries, national policies and local conditions are indiscriminately blamed, yet the phenomenon of high prices is manifest among all progressive nations and in a degree throughout the whole world. It is in evidence in all countries regardless of tariff policy and monetary standards. It is also apparent under all forms of government. If there is any one class of countries in which the phenomenon attracts less attention it is in those which are least advanced in civilization. Obviously many of the causes to which this general rise in prices has been ascribed must be fallacious because of its universal prevalence.

In explaining the causes it is essential to recognize three fundamental facts, very obvious in their nature, but not so readily understood in their bearing upon the present situation:

1. The rapid progress made by leading nations in modern times.

2. The striking inequality of this progress in different branches of human endeavor.

3. The inevitable tendencies in every progressive era to over-action in enterprise and extravagance and waste in expenditure.

The second and third facts are subordinate or incidental to the first and closely associated with each other. Let us explain the effect of each in its order.

1. Notwithstanding long periods of inertia and even of retrogression, the dominant note in the history of the race has been that of progress; this has been especially true in the last one hundred years. Scientific progress has always been in the van, followed by material, intellectual and political progress. Science has given to mankind a constantly increasing control over nature. Inventions and discoveries have greatly multiplied the supply of useful articles adapted to satisfy human wants. As a result, the convenience and luxuries of one generation are regarded as necessaries in the next. One marked effect of this progress is the alleviation of the struggle for existence, with the resulting leisure or opportunity to acquire greater skill and to discover new methods of production. The requirement of less effort for obtaining the necessaries of life gives a wider scope to human enterprise and makes it possible to multiply the achievements which contribute to the betterment of the race.

Nothing is more apparent than that the average per capita consumption is constantly increasing, not merely in essential food products, but in a variety of useful articles which are now available for more general use. Some tables prepared by the late Prof. Richmond Mayo-Smith set forth clearly the increased consumption of divers articles in several countries of Europe in periods of 20 to 25 years:

ANNUAL CONSUMPTION PER CAPITA IN DIFFERENT COUNTRIES IN DIFFERENT YEARS.

	1862	1882	Increase per cent.
Meat, France	25.9 kilos	33. kilos	27.41
	1868	1890	
Meat, England ..	100.5 kilos	124.5 kilos	23.88
	1871-75	1891-95	
Tea, Germany ...	.02 kilos	.05 kilos	150.00
Petroleum, Germany	3.75 kilos	14.82 kilos	295.20
	1871	1896	
Flour, United Kingdom	150. lbs.	257. lbs.	71.33
Tea, United Kingdom	3.91 lbs.	5.77 lbs.	47.57
Eggs, United Kingdom	12.6	40.	217.46
Butter and margarine	4.7 lbs.	11.1 lbs.	136.17
Cocoa	.23 lbs.	.62 lbs.	169.56
Bacon and ham..	3.4 lbs.	15.9 lbs.	367.64
Refined sugar ...	5.28 lbs.	41.53 lbs.	686.55

It may be noted that modern means of communication, the ready transmission of news and the increasing scope of industrial and commercial operations have brought about a solidarity of interest among nations and rendered it easy to obtain by international trade useful articles even from the remotest parts of the earth. These same forces have promoted political progress, the assertion of popular rights and a greater equality of opportunity. One effect of this has been that wealth and the consequent increase of average consumption are no longer limited to a favored few. The development of a more peaceful disposition among nations has caused a great increase in both production and consumption. Human effort has been less occupied with warfare and more with the development and utilization of the world's resources. All these factors make possible a rising standard of living which increases prices, unless there is equal progress in production.

2. Progress, however, has been notably unequal in the different branches of endeavor which supply human wants. It is necessary to keep in mind the difference between a rise in the price of certain classes of products and a general rise in the price level, to which reference will be made later. There is a substantial distinction between these two phenomena. New methods in industry and commerce are revolutionizing the means for supplying human wants, but their effect is far more helpful in some categories of products than in others. Whether this be the result of natural conditions or limitations upon our knowledge is not pertinent to this inquiry. The fact is obvious. Throughout all periods, notwithstanding changes in fashion and taste there has existed a demand amounting to a necessity for certain essential products, such as food, clothing and shelter. It is plainly evident that science, working through inventions and improved methods, has not accomplished the same results in agriculture, especially in food supplies, as in manufacture. The revolution in industrial methods and in the utilization of capital in large scale operations has not been accompanied by equal progress on the farm. Very considerable progress has been made, it is true, in carrying agricultural products to the market and in preserving them for use, but these pertain to transportation and to the middleman rather than to the original producer. Accordingly, as we should expect, the prices of farm products have risen much more rapidly than the prices of manufactured articles. In a very valuable report of the chief of the Bureau of Statistics for the Department of Agriculture for the year 1910, a comparison is made between the increase in the prices of articles purchased by farmers during the ten years from 1899 to 1909, and the increase in the value per acre of that which the farmers sell. For the articles purchased the average increase was 12.1 per cent, while for the products sold by the farmer the average rate of increase in the value per acre was 72.7 per cent, or six times as much. The comparison is made even more emphatic when it is noted that flour and lard, which show maximum, or nearly maximum increase in prices which farmers must pay correspond to the higher prices they obtain for their wheat and hogs. To this rise in the price of articles of food there is one general exception, namely, the price of tropical or semi-tropical products, most of which show a decrease for reasons which do not exist in the case of products of the temperate zone.

The rise in the prices of agricultural products in the temperate zones is well illustrated in the case of raw materials used in the manufacture of clothing. Until this present year the price of cotton had shown a steady increase. The price of middling cotton per pound in the year 1895 was 7.44 cents in the New York market; in 1903 it was 11.18 cents; in 1910, 15.11 cents, or twice as much as fifteen years before. The price of fine wool in the month of January, 1895—for most of which year there was no duty—was in the eastern markets 17½ cents; in 1903, 30 cents, and in 1910, 36 cents. It may be added that cotton and woolen cloth in their various forms show a much less increase in price than the raw products from which they are made.

The same general facts are true with relation to cereals and all other food products of the temperate zones. A cause additional to the lesser degree of assistance from invention may be found in the greater scarcity of land suitable for profitable cultivation, and in our own country especially the early cultivation of fertile areas was conducted with too much regard for immediate return and consequently little attention was paid to permanent productive quality. It is, of course, plain that farm products as well as all articles show an increased price by reason of the greater cost of wages and of most of the supplies which farmers must use. This, however, is common to all branches of production.

The unequal development in different lines of production has of late become especially noticeable in the case of precious metals. Formerly success or failure in gold or silver mining was largely a matter of chance. Now, however, as a result of the discoveries and improvements in engineering, and much more in chemistry, gold and silver mining has assumed the position of a settled industry in which calculations of the profitableness of treating certain ores or digging along a lode may be made with a fair degree of certainty. It may be added that improvements in production are unequal not only as regards different classes of useful articles, but also for different articles of substantially the same class. This is true of various lines of manufacture, hardly any two of which have been affected in the same degree. The manifest effect of this inequality in the case or difficulty of production is a change in their relative value.

3. There is an inevitable tendency toward overaction, misdirected energy, waste and extravagance in every progressive era. This tendency has its roots in the very characteristics of human nature itself. It is due in part to the measure of uncertainty which pertains to all business undertakings and in part to the ambitions and dispositions of men. Whenever a new process is invented for satisfying a human want or a new market is discovered, it is probable that the inviting prospect of gain will cause an undue amount of investment and effort in that new direction, which results in a loss of capital and an over supply of certain articles. The tendency to waste and extravagance is even more marked in the utilization of new facilities or the purchase of articles which please the taste or fancy. It is a well known fact that the desire for the automobile has caused many persons to invest in this new luxury who could not afford it. A new style of house, or equipage, or of dress, all of which are common in a time of increasing wealth often lead to the discarding of that which under less favorable circumstances would be regarded as sufficient, and to the purchase of other articles in accordance with present day tastes or fashions. Social ambitions and the desire for luxury tend in the same direction, extravagance grows as facilities and attractive articles multiply. Along with these factors is the desire for ease and luxury which accompanies the accumulation of wealth. This is but a result of the fact that pleasure is more attractive than pain; that enjoyment is preferred to effort, hence the number of the unemployed increases and the amount of effort made for satisfying human wants diminishes.

An important factor of the present situation as affecting the high cost of living is the rapidly growing cost of government, national, state and municipal. In case the proceeds derived from taxation are applied for essential improvements naturally no waste would accrue, but there are nevertheless substantial differences between public and private enterprise. The former is managed with a less degree of care and supervision. Given a certain object, the expense of securing it by public management is usually greater than under private control. There is a still more important factor. The aim and nature of public expenditures differ materially from private investments. The latter are made with a view to an adequate return, a profitable income on the amount expended; in many instances, the former look to objects of a less essential nature, sometimes to monuments of grandeur or of art, which do not subserve any immediate purpose of utility. Public activities are often undertaken for conserving health or maintaining more perfect order, and have in view considerations of general welfare most commendable in their nature, but such as would not be initiated in expectation of immediate profit. Again, they oftentimes provide for new facilities on a scale which private enterprise would not attempt. To all these must be added—and especial attention is called to this—the enormous burden of military and naval armaments now amounting, in the more civilized nations, to two billions per year, an economic waste which imposes an almost unendurable burden upon the world's resources. Again in prosperous times a disposition to indulge in excess and unwise undertakings is constantly manifest, both in public and private expenditures. So long as there are limitations upon our ability to forecast the future, this will be true. No more helpful consummation in commerce and industry could be wished than that which by careful weighing of future needs and probabilities could adjust present activity to future demand.

In this connection it must be stated that the inequality of the supplies of raw material requisite for human needs is a prominent factor in the situation. The lumber supply of the United States, which at one time seemed abundant and even inexhaustible, in view of the great demand for buildings, furniture, implements, etc., has been diminished to such an extent as to threaten an early exhaustion. Perhaps the wisest policy would have suggested that the State limit the cutting of timber and require that new forests be planted. How-

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ever that may be, the diminishing supply of timber in the face of unusual demand has caused a rapid increase in the price of products of the forest, the advance from 1900 to 1910 being the greatest of any single class. A comparison of the figures prepared by the Bureau of Commerce and Labor shows that between 1900 and 1910 the wholesale prices of wooden ware and furniture increased about 20 per cent, while the prices of window glass and grades of earthenware decreased nearly as much. For this divergence there is an evident explanation, namely, that the supply of timber is becoming more scanty, while that of sand and clay and other materials for glass and earthenware is inexhaustible and readily available.

There have been numerous illustrations of the increase in prices in the history of progressive countries. According to Boeckh, in the time of Solon, an ox in Athens cost 5 drachmas, or nearly 3 shillings; a sheep, 1 drachma; a bushel and 3 gallons of corn, 1 drachma. Two hundred years later the prices rose to five times and in many cases to ten or twenty times their former amount. The quantity of money was increased by the spoil obtained by successful military operations and by the development of mining in the islands of the Mediterranean, in Attica itself, and in Thrace and the island of Thasos. In Rome it is more difficult to trace the changes in prices of food. Corn was sometimes exacted as a tribute from conquered countries and sold by the State at less than cost and occasionally given away. The increase of prices was particularly rapid after the concentration of the chief mining industry in the hands of the Roman government. Cattle increased in price as well as corn. About 400 B. C. sheep sold for 7 pence 3 farthings (15½ cents). At the date of the Christian era the price was 25 shillings ($6.25). After the Carthaginian wars the Romans acquired the valuable mines of their enemies in the western part of Africa, also in Sicily, Sardinia and the south of Spain. A few years later the mines of Greece and Asia Minor came into the possession of the Romans; still later the mines of Macedonia and Thrace. In their later conquest, special effort was made to acquire supplies of precious metal.

In the year 1581 a dialogue was printed, attributed to one "W. S.," probably William Smith, entitled "A Discourse of the Common Weal of This Realm of England." The participants in the dialogue are a knight or owner of land, supposed to be Mr. Thomas Hales, a doctor of divinity, who as it is conjectured was Bishop Hugh Latimer, a husbandman, a tenant farmer, a merchant, a mercer and a capper. An enterprising publisher in the year 1751 republished this dialogue, and basing the authorship on the initials "W. S.," assigned it to William Shakespeare, a manifest effort to obtain a greater sale by deceit. The real date of the dialogue as appears from more recent investigation was the year 1549. This document is exceedingly valuable for students who are considering the subject of high prices, for if we leave out the influence of the larger aggregations of capital, and the characteristic features of modern business, practically every reason for a rise in prices is advanced in it. Each ascribed to the occupation of the other the responsibility for the existing situation. Views are expressed upon the benefits of protective tariffs against foreign products, upon the balance of trade, upon the exactions of the middleman, upon the increase in rents of agricultural land. One of the characters expresses the opinion that avarice is the cause of high prices. Another mentions the great increase in the cost of necessary articles. One of them says: "Within these eight years you could buy the best pig or goose that I could lay my hands upon for 4 pence which now costs me 8 pence, and a good capon for 3 pence or 4, a chicken for a penny, a hen for two, which will now cost me double the money; and it is likewise of great ware as of mutton and of beef." It was maintained in this discussion that price determined rent and not rent price. The husbandman conceded that if he were commanded to sell his wheat and other products at the old price he would have enough to pay his landlord as in times past, but he says that he must buy iron, salt, tar and pitch, all of which brought a higher price than formerly. One cause of the increase of prices, which is pointed out in this dialogue, is the clipping of coin which caused the good coins to go abroad for use in foreign trade. There were, however, more universal causes than this. Bodin, a French political philosopher, in the last half of the sixteenth century, states as an undoubted fact that there had been a revolution in prices. He gives six reasons for it:

1. The great abundance of gold and silver, which resulted in a decrease in its purchase power.
2. The monopolies of the guild and of the tax farmers.
3. The ease with which wine and corn—the chief products of France at that time—might be exported, thus increasing the price at home.
4. The extravagance of the court.
5. The general leisure in the community.
6. The debasement of money, a practice which was prevalent in France at that time.

Mr. Jacob, in his excellent work on precious metals, ascribes the increase of prices, of which complaint was made in the dialogue referred to, to the increased production of the precious metals and traces with great research the coincidence between their increased supply and the high prices of that time. A similar object lesson in the history of prices is derived from a comparatively recent period. In the years from 1789 to 1809, the average price of commodities rose from an index figure of 85 to 157, or more than 80 per cent. There were other contributing causes, such as the prevalence of war and the interference with international trade caused by the French Revolution and the Napoleonic wars. Mr. Tooke lays stress upon the poor harvests of that period, but Prof. Jevons ascribes the increase to the larger production of gold and silver, and points out that metals and oils were more affected than grain. Beginning in 1809, for a period of 40 years, prices fell from an index number, as measured by Prof. Jevons, of 157 to 64, or nearly 60 per cent. This decrease has been very generally ascribed to the falling off in the production of precious metals which did not revive until the gold discoveries in California and Australia. There was a temporary rise after 1830, apparently due to the inflow of Russian gold following its discovery in Siberia in 1830. The great activity prior to 1837 was also a contributing cause. It should be carefully borne in mind that this period from 1809 to 1849 was a time of great industrial advancement in which many inventions and improvements were utilized. In the period from 1849 to 1873, prices rose from 64 to 86, or about 34 per cent. The rise was interrupted by the crisis of 1857 and 1866, and greatly accelerated by the exceptional activity prior to 1873, and was presumably due to the gold inflation following the development in 1849 in California, and several years later in Australia. In the period from 1873 to 1896 prices fell in gold countries, and this is ascribed to the decrease in the production of gold, to the adoption of the gold standard in the more advanced nations, thereby discontinuing the general use of one of the precious metals, at least as far as free coinage was concerned.

Manifestly there were other causes for the decrease in prices at this time. The great increase in facilities for transportation, culminating with the opening of the Suez Canal in 1869, brought different portions of the earth nearer to each other and made it possible to utilize the abundance afforded by outlying districts for the benefit of the more settled areas where food products were becoming less abundant. Again there were most notable increases in the mechanical arts. So considerable was this decrease in prices that several writers, of whom perhaps Mr. David A. Wells is the best example, came to the conclusion that the period of the most buoyant activity had come to an end; that thereafter the people would occupy themselves with repair and replacement or in utilizing discoveries already made. In other words, the most profitable production had reached a limit.

A very valuable contribution to the subject of prices is furnished by a comparison between gold and silver standard countries. In India, where silver was still the money of the people, the index of prices rose from 107 in 1873 to 140 in 1896. In Japan it rose from 104 in 1873 to 133 in 1896, or a little less than 20 per cent, while in gold-using countries prices fell off more than 20 per cent. From 1896 to 1909 there has been a rise in prices contemporaneously with a great increase in the quantity of gold mined in South Africa and in different portions of the United States and Alaska.

Let us draw a little more fully the comparison between these eras of high and low prices and the production of gold. From 1789 to 1810, it has been stated that there was a rise in prices. During these years the average production of gold in the whole world was a little less than $12,000,000 per year, and that of silver approximately $37,000,000, or $49,000,000 in all. Beginning in the year 1811 the annual average for the next ten years was $7,606,000 of gold or a diminished supply of more than 33 per cent and $22,000,000 of silver, a diminished supply of about 40 per cent. In the following decade from 1821 to 1830 there was an increase in the mining of gold and a decrease in that of silver, but the total annual average was slightly less than from 1811 to 1820. From 1831 to 1840 there was a substantial increase in both metals amounting to about 33 per cent. From 1841 to 1850 gold production increased from about $13,000,000 per year to $36,000,000. However, in the forty years from 1811 to 1850, inclusive, an era of low prices, the average annual production of gold, was barely $17,000,000 per year; then by the opening of the mines in California and Australia the average suddenly rose from $17,000,000 to over $130,000,000, and to a still greater figure from 1856 to 1860. This was a period of rapidly rising prices. After this there was somewhat of a decrease. The lowest annual production was for the four years, 1874-75-76 and 1883, in each of which the production was between ninety and a hundred millions. A practically uniform and very large increase commenced in the year 1891 with $130,000,000, which increased to the enormous figure of $236,000,000 in 1897, after which with slight interruptions resulting from the Boer war, the still higher figure of $454,000,000 was reached in 1909. It thus appears that the production for the single year 1909 was more than two-thirds as much as for the forty years from 1811 to 1850. It was greater than the combined coinage value of gold and silver for any year prior to 1898, and five times as great as the production of gold in the year 1874.

A further fact to be taken into account, of course, is the relation of the annual increment to the accumulated supply. Divers estimates of the world's stock of gold have been made. That which should be considered in the portion used for money in the form of coin or bars of bullion. At the present time the annual production is equal to at least three and perhaps four per cent of the total existing monetary supply. Of the $454,000,000 mined in 1909, it has been estimated that $145,000,000 was utilized in the arts. It is probable that this is a large estimate, but in any event the primary money of the gold standard countries was increased by $300,000,000 in the year 1909. Indeed, according to the very carefully prepared estimate of Mr. Roberts, the director of the mint, the amount of coinage for that year is given as $313,000,000.

It is not by the mere addition of gold to the monetary supply that prices are raised. There is an even more important stimulus to activity in the fact that this money is used as a basis of credit; that countries which heretofore have been without railroads and modern facilities are enabled to borrow for the construction of great railway lines and public works, the full benefit of which is often for a long time postponed. There is a marked increase in the demand for materials for this work. Labor is more constantly employed and at higher wages. The consuming power of the average human being is greatly increased. Speculation is rife and this tends to raise prices.

The connection between the increased supply of the precious metals, and the general level of prices has been so marked and has appeared in so great a variety of countries and of periods as to preclude the possibility of mere coincidence. Of course certain modifying factors should be taken into account. The rise in prices after the beginning of the increase in the supply of gold or silver does not become manifest until some time has elapsed. This can be readily explained, because a substantial increase is necessary to modify the relation between the existing stock of the precious metals and the accretions.

Again, there has usually existed a concurrence of factors which make for increased activity and rising standards of living on the one hand and the increased supply of the precious metals on the other. The development of gold mining on a large scale has followed closely after discoveries and inventions. This concurrence is such that while it would hardly be safe to generalize upon it, there is a strong presumption of a connection between the two. A somewhat similar cause of the rise of prices, by reason of the increased supply of gold among the militant countries of the ancient world, may be traced in their activities to secure the control of mines from which the precious metals were obtained.

The foregoing facts emphasize the importance of the so-called quantitative theory of money in considering the question of prices. To give adequate treatment to this theory and to estimate the effect of the volume of money upon prices would prolong this paper to an undue length. It would manifestly be incorrect to state the relation of the volume of money in circulation to the general level of prices as a simple equation. The problem is much more difficult. On this subject Mr. John Stuart Mill wrote in his work on Political Economy:

"The proposition respecting the dependence of general prices upon the quantity of money in circulation must be understood as applying only to a state of things in which money—that is, gold or silver—is the exclusive instrument of exchange, and actually passes from hand to hand at every purchase, credit in any of its shapes being unknown. When credit comes into play as a means of purchasing, distinct from money in hand, the connection between prices and the amount of the circulating medium is much less direct and intimate and such connection as does exist no longer admits of so simple a mode of expression."

Certain modifications are necessary in order to harmonize the quantitative theory with modern conditions. Only the amount of money actually in circulation can have any effect upon prices. That hoarded or out of circulation for other reasons cannot exert any influence. On the one side account must be taken of the variations in volume of transactions during periods of prosperity or depression and even at different seasons of the year. This factor affects the demand for the medium of exchange. On the other side allowance must be made for the rapidity of circulations and the use of credit instruments which reinforce the monetary supply and thereby modify its influence upon the price level.

There are sundry current explanations of the present high prices which may be readily dismissed as untenable if advanced as a reason for the general rise in the price level, however applicable they may be to the increase in the price of specific articles. What shall be said of the influence of the so-called trusts on prices? It is clear that complete monopoly or preponderant control of the market in the production or sale of any particular commodity affords opportunity to increase its price. The same result is apparent when separate producers maintain an agreement or understanding as to prices.

On the other hand, the superior economy and efficiency of large scale operations materially diminishes the cost of production and even more of distribution and should, therefore, tend to decrease prices. For this reason the concentration of industrial and commercial enterprises is a legitimate phase of business evolution. It must be said, however, with equal emphasis that thus far the general public has not experienced in reduced prices the benefit to which it is entitled because of the increased economy and efficiency resulting from great combinations. If the people do not receive their proper share of the benefits, strict control beginning with greater publicity and ending perhaps with the regulation of prices is the inevitable outcome. Certain it is that large scale operations have come to stay. If they cannot be successfully regulated, it is probable that State ownership will be adopted in preference to a return to the old regime of smaller competing units.

In a majority of cases the statistics of prices do not bear out the assertion that the establishment of large corporations has always caused an exceptional increase in the cost to the consumer. In many instances, the higher prices are due in part at least to the greater expense of obtaining raw materials or to the increased labor and obsolescence charges to which all concerns of whatever magnitude are alike subjected. In the table prepared by the statistician of the Department of Agriculture, to which reference has been made, it appears that among over eighty enumerated articles purchased by the farmer, there were only three, the cost of which diminished between the years 1899 and 1909. Two of these are comparatively unimportant, the third is coal oil which fell off from 15.1 cents per gallon in 1899 to 14.2 cents in 1909. There were substantial reductions in the prices of various forms of iron and steel in the same period, while, as already mentioned, those of practically all the agricultural products of the temperate zone increased.

The rise in the price level cannot be ascribed to tariffs any more than to the trusts, though prices of particular articles may have been increased by them. In answer to those who maintain that the tariff is responsible for the high cost of living in the United States, attention may be called to the admitted fact that the rise in the price level has been universal under free trade, as well as under revenue and protective tariffs. In a certain newspaper published at Paris last September, there were paragraphs giving accounts of meetings, some of which were attended by violence, in Berlin, Switzerland, Bohemia, Silesia, and Galicia to protest against high prices. In other issues at about the same time there were paragraphs giving accounts of bread riots in France and of loud complaints against the high cost of living in England and Belgium.

It is a noticeable fact that many prices have risen in spite of reduced tariff in our own country, as in the case of hides and shoes. In the whole list of increases in prices from 1899 to March, 1910, there is no more notable illustration than that of crude rubber, on which there is no duty. The price rose from 80 cents in the former year to \$1.99½ in 1910. On the other hand, raisins and prunes, upon which there is a considerable duty, have shown a material fall, and sugar has not greatly increased in price except very recently, owing, it is claimed, to crop conditions. Instances might be indefinitely multiplied of the rise and fall of prices here and elsewhere irrespective of the duties levied. These illustrations show that the tariff is only one of the numerous causes affecting relative prices. It may often happen, as in the cases cited, that other causes so far outweigh the influence of the tariff, that its effect cannot be discerned.

As regards the cost of labor, while a high standard of wages is maintained in the United States, and there have been notable increases in the wages of many classes of employees, it cannot be said that there has been a disproportionate increase; the facts are quite the contrary, because, generally speaking, the cost of living has more than kept pace with the increase in compensation.

As a rule, wages as well as retail prices do not immediately respond to changes as readily as wholesale prices or as rent and other items which go to make up the ordinary expenses of living. The basic fact which should be considered is the relative proportions of personal service and of improvements accomplished by inventions or labor-saving devices, in the production or distribution of any commodity. In cases in which machinery renders a more efficient service than formerly, the tendency is toward downward prices, but in case labor or personal service has been only partially aided by these improvements, or as in some cases not at all, the prices have increased.

Under modern systems of distribution the amount of personal service required is relatively much greater than formerly, and in this fact may be found a very important cause of high prices. Much more care is exercised in the preparation and handling of packages. Delivery is made to the consumer at his residence. There is not sufficient organization in distribution. As a result there is a vast amount of duplication. This service involves an exceptional cost as compared with the work of distributing large quantities. For example, the carrying of a ton of coal 150 miles to a city costs less than the transfer of that coal for a half or even a quarter of a mile to the home in which it is consumed. The cost of delivery of mail matter by carriers in cities and on rural free delivery routes is much in excess of the carriage in bulk by railway or steamship, even for very long distances.

Innumerable examples may be given of the very considerable difference between the original cost to the manufacturer and the final charge to the consumer. Some weeks since figures were carefully prepared in regard to the manufacture and sale of an article of clothing now in very general use. The manufacturer charged \$24.90 per dozen. Each dozen included different sizes. The retailer charged from \$4 to \$10 per garment. The total sales averaged about \$6.50 for each, or a total of \$78 to the consumer as against \$24.90 to the manufacturer. The retailer is not to be blamed. The pressure of population in cities, the greater demands of modern life resulting in higher rents and higher cost for services rendered to him, make it essential that he should charge more for the goods he sells.

An entire revolution in methods of distribution is imminent. The consumer will be brought nearer to the producer. Great warehouses will be substituted for small and scattered shops, especially in case of staple articles where confidence in the seller or exceptional skill are not essential features. The possible economy of large scale production and the undertaking by one organization of the various processes, even from the raw material through manufacture and distribution to the consumer, has been demonstrated by some of the great corporations of the country. However much we may decry this tendency, we may be reasonably certain that it will be adopted more and more in the future.

It would be rash to predict an early return to low prices. All the great factors which I have partially portrayed depend upon new conditions which have arisen, some of which are inseparably connected with substantial benefits to the human race. If prices have increased, human enjoyment has increased also.

That which is most noticeable in the consideration of this problem is the wide variation in the changing cost of divers commodities and facilities. After making due allowance, however, for this variation, there is a manifest increase in the general price level. Great economic laws will be potent in their effect upon these conditions. The enormous increase in the production of gold will be checked as this metal becomes less valuable in comparison with useful articles. Indeed, this fact is already forecast by the diminished annual increase in the years 1910 and 1911. Whether or not there be a movement "back to the farm," more scientific methods in agriculture will respond to the increasing prices of farm products. There may be some readjustment in population between the city and the country, but whether this is so or not the average yield per acre will no doubt increase. More intelligent and more adequate control will be exercised over great industrial and commercial organizations, so that the benefit of modern developments in industry and commerce may accrue in proper measure to those of limited means.

The same advances which have been made in production and in the distribution of great masses of commodities will, as far as possible, be applied to the minutest details of distribution. Our natural resources which have been wasted, or too largely absorbed by the few, will be more carefully utilized and every possible means be taken to preserve a proper share of them for the future. Thus in this present increase of prices, as in all great economic changes, there may be reasonable assurance that the ultimate effect will bring to all substantial benefit rather than harm.

The Sun as Insect Powder.—The British physician, Dr. Cunningham, has made extensive experiments in India regarding the extermination of vermin, as these tormentors had become dangerous to the community as carriers of diseases in the hot zones. It was found that fleas were unable to endure exposure to sun for any length of time. One hundred fleas had been hidden in a piece of carpet which was placed in a tin receptacle, and the whole was exposed to the sun. They attempted to escape from the rays of the sun. Those on top of the carpet piece died within seven minutes, those hidden under the carpet were dead within one-half hour.

Trade Notes and Formulæ

Blue Lettering on Steel Blades.—The blades are heated until blue. The letters are then applied with the aid of oil colors and a small hair brush. As soon as the characters are dry, the blade is immersed in strong vinegar. The bluing will then disappear except on the parts covered by the oil color. This is finally removed with the aid of a piece of soft rag dipped in oil of turpentine, whereupon the blue letters become visible.—*Prakt. Wegweiser.*

Cleaning Copper Engravings.—Make a solution of 40 grammes ammonium carbonate in 1 pint of water and go over the engraving (both sides), using a sponge or soft brush; then rinse with clear water. Then wash with water to which has been added some vinegar and rinse out again; to finish go over the whole with water in which has been dissolved a small quantity of bleaching powder. Dry in the open, preferably in the sun. The engraving will look like new, the treatment to which it has been subjected leaving behind no traces whatever. —*Neueste Erfind u. Erfahr.*

A New Preservative Medium for Museum Specimens. —The following is the invention of Wickerscheimer of the Berlin Zoologic Museum, the solution being used there for fixing and preserving plants and animals in their natural colors, being superior to the old "Kaiserling fluid" hitherto used. This solution is prepared by dissolving 100 grammes alum, 25 grammes sodium chloride, 12 grammes potassium nitrate, 60 grammes potassium carbonate, and 10 grammes arsenious acid in 3,000 cubic centimeters hot water, to which is then added 1,200 cubic centimeters glycerine and 300 cubic centimeters methylated alcohol. Objects preserved with this liquid retain their form, color and suppleness to a remarkable degree. Even after a considerable length of time they still appear fresh and pliable.

Fireproofing Tobacco-pipe Bowls.—The bowls are placed in a solution of 1 part silicate of soda in 4 parts of water, and left there for three to four days. They are then taken out, dried in the air and again placed in the same solution. The following day they are dried again, and immersed in a bath consisting of equal parts by weight of alum and zinc sulphate dissolved in hot water. After two or three days they are taken out and dried carefully. They may then be polished or varnished. Bowls thus prepared are absolutely fireproof.—*Zeitschrift für Drechsler.*

Paper Board for Driving Belts.—Paper boards which can be worked up into driving belts and for various purposes as a satisfactory substitute for thick leather can be made from hemp rope, ground for 36 to [illegible] hours in the small hollander and made in the cylinder wire machine. To render them impermeable to water, these boards are coated with paraffin wax or with animal glue solution and afterward treated with formaldehyde. Strips about 4 inches wide cut from such boards and joined by rivets to make a long belt showed no change after the belt had been in use six months.—*Paper.*

Bending Ivory.—The ivory to be bent is first treated with pure benzine in order to remove any grease. It is then placed in boiling water. Thin-walled articles should be left from 15 to 17 minutes in the water; those having thicker walls must be boiled for [illegible] minutes, but not longer. The articles should be taken out as soon as they are soft enough to permit bending. The drying should be done slowly and uniformly. Another way to bend ivory is to treat it with phosphoric acid, which makes it soft and flexible. As soon as it is removed from the acid bath it must be thoroughly washed in rain water and at once bent either by hand or with the aid of mechanical appliances. It is then placed in warm water and allowed to harden. Care should be taken that the articles of bent ivory do not touch each other during the hardening process.—*Gummi Zeitung.*

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